Analysis of prostate cancer patients’ stay time in Gunma University Heavy Ion Medical Center using RFID Technology

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Abstract – Using Radio Frequency Identification Device (RFID) technology, we tried to do tracking of patients treated at Gunma University Heavy Ion Medical Center. Data obtained on prostate cancer patients with total treatment duration of at least 15 days and having complete clinical information in our Hospital Information System are analyzed from September 2010 to December 2010 and from April 2011 to July 2011.

We did comparison of patients’ stay time in treatment unit and examination room, among the treatment days within the period as well as between the periods. The results reveal that as compared to first day, stay time in treatment unit is significantly reduced in the last few days of treatment. The reduction is more prominent during the second period (p=0.002 on 14th day and p<0.001 on 15th day). When both the periods are directly compared, stay time of patients in the treatment unit on the last day of treatment is significantly lesser in the second period (p=0.01) compared to the first period. However, there is no significant difference in patients’ stay time in examination room in any point of time.

Comparison of the data obtained during the two defined periods shows that it is feasible to assess utilization of the center using RFID technology. Such assessment may pave a way to generate patient scheduling algorithms in future, which will ensure the maximum possible utilization of such an expensive treatment center.

Keywords – RFID; patient tracking; stay time; prostate cancer; health care; Heavy Ion Center

I. INTRODUCTION

Radiofrequency Identification Device (RFID) is a short-range wireless electromagnetic field technology used to communicate digital information between a stationary location and a movable object or between movable objects. Use of RFID based unique identification of objects is presently being explored in many sectors. In health sector, RFID has potential role in tracking patients and staff, tracking and inventory management of medical equipment, maintaining effective error-free medicine supply chain etc.

Tracking patients and staff is shown to be useful in assessing and optimizing resource utilization. Kim et al [1] have shown how a RFID based Patient Management and Tracking System (PMTS) can increase patient convenience by monitoring location information of patients and managing the hospital’s waiting-list accordingly. In a French study performed at an Academic Ambulatory Surgery Center, RFID based data collection technique was used to predict the peri-operative admission duration of 1520 patients. Scheduling subsequent discharges from hospital based on that prediction helped them to provide an accurate timely discharge in 76% of new patients [2]. RFID based real time tracking system has been tried in a few small healthcare clinics to optimize the use of scarce resources. Notable examples are study by Chen et al [3] and Lin et al [4], where they found using RFID based data that non value added processes (e.g. waiting for healthcare personnel) consume around 37% and 60% respectively of patient’s total time inside the clinic. This non-value added time duration can be reduced by appropriate scheduling. However, data about RFID based patient/staff tracking and scheduling is still very limited. Specifically, in Japan, research and implementation of RFID technology in healthcare sector is considerably lagging behind.

Heavy Ion therapy is a relatively newer and more effective mode of radiation therapy in cancer. Due to high infrastructural cost, this treatment facility is sparsely available (as of April 2017, only 11 centers operating across the globe). This mandates the most effective utilization of the available centers giving maximum benefit to the society. RFID based tracking has not yet been tried in any Heavy Ion therapy center. Hence we had chosen our existing Heavy Ion therapy facility at Gunma University Heavy Ion Medical Center (GHMC) for RFID based tracking system.

We found that the number of prostate cancer patients treated at GHMC is higher as compared to the other cancers. So, we decided to analyze the stay time of prostate cancer patients in the first phase of our analysis to observe the utilization of the valuable treatment unit and examination room.

II. MATERIALS AND METHODS

The Institutional Review Board (IRB) of Gunma University approved this study (reg. no. 2016-030).

The RFID system at GHMC (made by TOPPAN FORMS, Tokyo, Japan) uses a frequency band of 93.75 kHz and 300 MHz. All patients and staff at GHMC are being issued a specific semi-active IC tag (MXAT-MV-14, MATRIX, Osaka, Japan) routinely since September 2010. When they pass by a tag reader (300 MHz, MSRD-ST-2-
100, MATRIX, Osaka, Japan) near a door, the IC tag can be activated by two trigger coils (93.75 kHz, MXTU-ST-201, MATRIX, Osaka, Japan) on the ceiling and floor. Thus the information that they enter/leave, to/from a room corresponding to the gate controller is read. Ubic Safe (TOSCO CORPORATION, Okayama, Japan) executes the entrance/exit management of the room. In this entrance/exit management system, whether there are patients and medical workers within a room is detected on the basis of the collected information and the record is directly stored in the server. This enables accurate estimation of stay time in the set area (Figure 1). The RFID system is in compliance with the report by The Ministry of Internal Affairs and Communications, Japan in 2014 that electromagnetic interference by RFID system (93.75 kHz and 300 MHz) did not have adverse effects on medical devices including cardiac pacemakers and implantable cardioverter defibrillators.

Data from September 2010 till July 2011 have been retrieved for this preliminary analysis. To ensure homogeneity, only prostate cancer patients with total treatment duration of at least 15 days and having complete clinical information in our Hospital Information System are analyzed. If we do not find any patient data on a particular day due to holiday or any other condition (e.g. system maintenance), that day is excluded from analysis.

Time periods evaluated in our study are from September 2010 to December 2010 and from April 2011 to July 2011 (patient treatment at GHMC was temporarily suspended from January 2011 till March 2011 due to system maintenance). A comparative study of the above periods is performed by tracking the patients, to see trend of the treatment unit and examination room utilization with respect to time.

We have three treatment rooms but to avoid any ambiguity we consider all of them as a single unit during this study. Daily stay time of patients in treatment unit (total stay time consists of actual treatment and setting up of patient for treatment) and clinical examination room are obtained from the RFID tag time stamps, based on the entry sequence of a particular tag among rooms. For example, if tag ID A enters into room X and then to room Y, the time difference between both is taken as the stay time inside the room X. Stay time of lesser than 5 minutes in treatment unit are excluded from the analysis, due to possibility of erroneous data capture by RFID antennae.

Data of all eligible patients treated during the period of September 2010 to December 2010 is merged. From the merged data, patient’s stay time values in treatment room on 1st day is compared to that on 2nd, 3rd, 4th and so on till 15th day (i.e., the last treatment day for most of the patients) using paired two tailed t-test. This was done to check whether pre-treatment setting up requires same or different amount of time as a patient’s treatment proceeds. Similar procedure was applied for patients treated during April 2011 to July 2011. Thus two unique datasets corresponding to the two periods are created. To check the trend with time since installation of GHMC, day-wise stay time of patients between the two periods is compared by using unpaired two tailed t-test. Average stay time of patients in each period is calculated and both are compared. All comparisons have been done for both treatment unit and examination room separately.

III. RESULTS

A total of 50 patients were eligible for analysis. Out of them, 25 patients got treated during September 2010 to December 2010 and the remaining 25 got treated during April 2011 to July 2011.

We noticed that in comparison with 1st day of treatment, the stay time in treatment unit are significantly lesser on days 6th (p=0.02), 8th (p=0.03), 9th (p=0.04) and 14th (p=0.03) for the period of September 2010 to December 2010. On the other hand, for the period of April 2011 to July 2011 we found that patient’s stay time in treatment unit as compared to that of 1st day of treatment are significantly reduced on 7th (p=0.01), 8th (p=0.02), 10th (p=0.01), 11th (p=0.02), 12th (p=0.001), 13th (p=0.01), 14th (p=0.002) and 15th (p<0.001) day.

When both the periods are directly compared, we found that there was a statistically significant reduction (p=0.01) of stay time in treatment unit on 15th day of treatment during April 2011-July 2011 compared to September 2010-December 2010 (Figure 2) and rest of the days were non-significant.

![Fig. 1. When a TAG enters a specific area covered by trigger antenna (93.75 kHz), the TAG ID signals are sent to the receiver (300 MHz).](image)

![Fig. 2. Comparison of average stay time in treatment unit during the studied periods. Error bars represent the standard deviation. * p<0.05 as compared data from April 2011 to July 2011.](image)
IV. DISCUSSION

Stay time of a patient in treatment unit consists of actual treatment and pre-treatment setting up time as already mentioned. For each patient, during the initial days of treatment to ensure accuracy of positioning the pre-treatment setting up usually takes long time. This set up time which depends on patient’s compliance and staff skill, is assumed to gradually reduce in due course of time. Our finding of statistically significant reduction in stay time inside treatment unit as patient’s treatment proceeds is concordant with the assumption.

The reduction in stay time in later days of treatment is more prominent during the second period (March 2011 to July 2011). Moreover, when both the periods are directly compared, stay time on the last day of treatment in the second period is significantly lesser than that of first period. This suggests that overall patients are taking comparatively lesser pre-treatment setting up time during the second period. This can be attributed to gradual increase in efficiency of staff with time since installation of GHMC (an extra amount of time might be required for patient preparation during the initial phase of functioning of the center). On the other hand, examination time is similar throughout the time, showing it is independent of the treatment facility installation status.

Our study shows that RFID technology is a feasible method to track patients and hence to assess resource utilization efficiency. In future, we aim to analyze the data of healthcare personnel in addition to patients (of various malignancies) for a longer period of time. Based on the tracking results, we plan to develop a scheduling algorithm for patient management in our Heavy ion therapy center. This is expected to help both already established as well as upcoming Heavy Ion Centers around the world to ensure the most optimal resource utilization and thus delivering best possible patient care.

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REFERENCES