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DESIGN AND DEVELOPMENT OF A PATIENT LIFTER FOR BRACHYTHERAPY PROCEDURES IN CERVICAL CANCER TREATMENT

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ABSTRACT

The role of a patient lifter in brachytherapy is crucial for ensuring safe and efficient patient transfer during treatment. The use of fabric slings for patient transfer in brachytherapy at MRCCC Siloam Hospitals Semanggi is considered ineffective as it requires at least 6-7 medical staff to move a patient. The development of medical devices, such as brachytherapy patient lifters, is critical for maintaining safety, as any failure or malfunction can cause serious injuries to both medical personnel and patients. This study aims to design a brachytherapy transfer table and evaluate its effectiveness in minimizing physical strain on healthcare workers during patient transfers. Research methods implementing a rigorous development process is essential to minimize the risk of failure by ensuring that validation and verification activities are conducted objectively, reproducibly, and are well documented. This research introduces an approach based on the formal R&D Borg and Gall method for developing brachytherapy patient lifters. Results Functional tests demonstrated the overall success of the brachytherapy patient transfer table, with a 100% validity rating from five experts. The test results showed a significant value of 0.000, less than 0.05, indicating a significant difference between conditions before and after the design of the patient transfer table. The development of the brachytherapy patient transfer table has been highly successful and effective at MRCCC Siloam Hospitals Semanggi. The device also holds potential for further development in studies with larger sample sizes.

Keywords: *Patient Lifter Table, Brachytherapy, Cervical Cancer*

INTRODUCTION

One approach to curing cancer is radiation therapy. Radiotherapy is a therapy that uses ionizing radiation to destroy cancer cells. Based on the type, there are two types of radiotherapy, namely, external and internal radiotherapy. As mentioned above, external radiotherapy utilizes a source of ionizing radiation from outside the body while internal radiotherapy utilizes radioactive particles, such as radioactive isotopes adjacent to the primary malignancy, providing continuous and accurate radiation (1-4). Internal radiotherapy, one of which is brachytherapy, is often used for gynecological cancers, such as cervical cancer, as monotherapy or additional therapy after external radiotherapy (5). Cervical cancer is cancer that grows in cells in the cervix. This cancer is generally higher in low-income countries, most likely due to limited access to screening and the high cost of the HPV vaccine (6). The cervix or cervix is the part of the uterus that is connected to the vagina. The cervix has a unique and vital function for both non-pregnant and pregnant women because it functions to regulate fertility, support pregnancy, and ensure the safe birth of a full-term baby during childbirth (7).

The fundamentals of brachytherapy rely on the implantation of a radioactive source (or an applicator filled with a radioactive source) placed within the tumor or very close to the tumor (8,9). Implantation was performed based on clinical findings from relevant imaging. The majority of radiation sources used in internal radiotherapy are radioisotopes which emit low-energy gamma rays so they can deliver high doses to the tumor while protecting at-risk organs around the tumor (10). Based on the type of source placement, the radiation source in brachytherapy can be done interstitial, intracavitary, or by combining both techniques (11–13). The interstitial technique is a form of internal radiation that 2 involves intraoperative placement of a radioactive source into the tumor or resection cavity (14). Placement of the intracavitary applicator is done by placing the applicator into a body cavity such as the vaginal cavity (15). In cases of gynecological cancer such as cervical and endometrial cancer, the radiation source will be installed intracavitary using tandem and ovoids, tandem and ring, and tandem and vaginal cylinders (11). The use of a combination of interstitial and intracavitary techniques involves the insertion of transvaginal and/or perineal needles along with tandems and rings or ovoids, using special applicators or freehand placement (16).

The brachytherapy procedure includes the process of moving the patient from the preparation room to the CT simulator room, and then to the brachytherapy room. The patient-moving procedure is closely related to the use of a tool known as a patient lifter. A patient lifter refers to a device that assists in the process of lifting and moving patients between various places such as beds, stretchers, chairs, wheelchairs, and toilets (17). The process of moving patients from one room to another relies

on the ob-gyn table which is pushed by health workers. After a CT scan, the patient will be lifted using a cloth mat and moved using an ob-gyn's table to the brachytherapy room for deep radiation. After the internal radiation is complete, the patient will be moved using the same table to the procedure room to remove the installed applicator. The process of transporting and moving the patient can cause movement of the applicator even with the help of immobilization devices (18). Apart from the possibility of movement of the applicator, the process of manually moving patients can cause an increase in work accidents among health workers (19). Frequent patient transfers, weightlifting, and patient mobilization have been proven to be risk factors for low back pain such as cases of Herniated Nucleus Pulposus (HNP) (20). Every day, healthcare workers seeking to improve and protect patient health face physical risks from repeated transfers and pose risks to both patients and therapists with the possibility of equipment failure (21,22).

This is related to ergonomic values in the scope of patient and worker safety in the world of health. Applying ergonomic values in a disciplined manner can provide system concepts and methods to improve treatment processes and outcomes for patients, nurses, and doctors (23). According to the International Ergonomics Association (IEA), Human Factor Ergonomics (HFE) is "a scientific discipline concerned with understanding interactions between humans and other elements of a system and a profession that applies theories, principles, data, and methods to design to optimize human well-being and overall system performance" (24). Jaejin Hwang et al. in their study reported that making adjustments from manually transferring patients to using patient transfer aids could reduce the risk of accidents (25).

The process of transferring brachytherapy patients at this hospital uses a cloth mat to lift the patient from the ob-gyn's table to the simulated CT table for scanning, and then to the patient's table for brachytherapy. This process required five to seven staff, which was considered unergonomic due to varying patient loads and erratic shift schedules. Adjusting the height of the ob-gyn table with a simulated CT table often forces officers to bend or squat, which is unsafe from an ergonomic perspective. To minimize the movement of the implanted applicator and improve the safety of staff and patients, efforts are needed such as designing a table that meets ergonomic standards as a tool to help move patients. Therefore, researchers are interested in conducting research regarding the design of a moving table for brachytherapy procedures for clinical cervical cancer.

RESEARCH METHODS

The type of research used in this research is Research and Development (R&D). This research aims to design and develop a patient transfer device inspired by the ob-gyn's table. The stages of this research refer to the R&D procedure created by Borg and Gall (1983) which consists of Information Gathering, Planning, Initial Product Development, Expert Validation, First Revision, Initial Trial, Second Revision, Field Test, Final Product Revision, Dissemination (26). The Borg and Gall stages can be seen in Figure 1. The materials used in making the prototype for this research used materials such as Multlipex / Wood which is used as a molding material for making brachytherapy patient transfer tables. Carbon fiber is used to cover fiberglass tables to make the table stronger. Stainless steel, used for brachytherapy patient moving table trolleys. Foam is used as a foot support material in the lithotomy position. The prototype design can be seen in Figure 2.

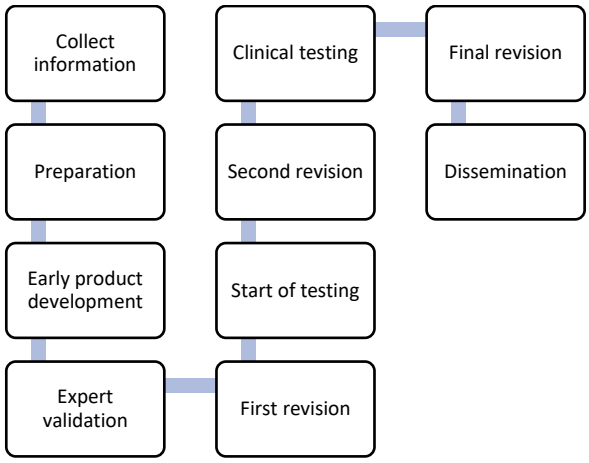

Figure 1. Process R&D Borg and Gall

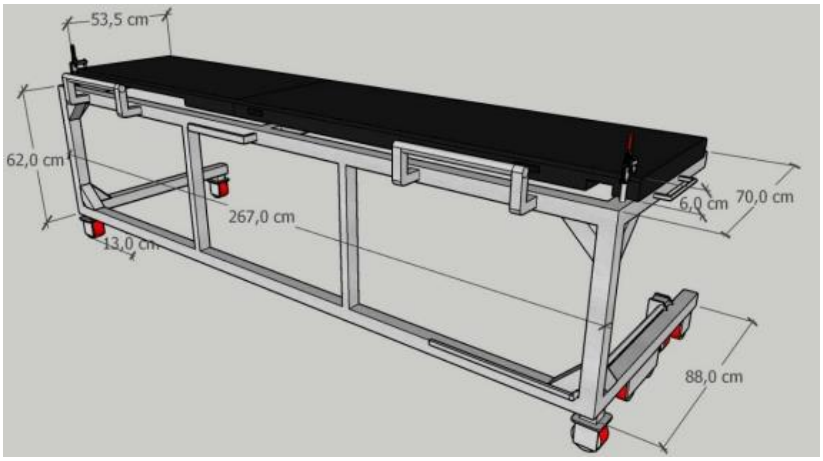

Figure 2. Brachytherapy Patient Transfer Table Prototype Design

This study also used research subjects such as cervical cancer patients who underwent brachytherapy. Determination of the sample size using the Lemeshow equation with results for 96 patients. The next subject is as a product validator by a radiation oncologist, head of Facility Management Service, senior radiotherapy radiographer, occupational safety and health officer, and ergonomist. Product validation was carried out using expert validity questionnaires and the Rapid Entire Body Assessment (REBA) test (27-29). The next subjects were 40 treatment quality acceptance test respondents, namely 16 radiotherapists, 3 nurses, 4 medical physicists, 5 radiation oncologists, 7 residency medical physicists, and 5 field work practice students.

The data processing method used in this research uses statistical analysis. The collected data will be analyzed and interpreted to further test the hypothesis. Function Test Analysis in the form of nominal data that is functional and non-functional after providing a questionnaire regarding the function of the tool that has been made. Filling in the checklist for whether the tool is functioning or not will be a determining factor in the functional test analysis process. Validity Test Analysis in the form of valid and invalid nominal data after giving a questionnaire regarding the validity of the tool that has been created. Filling in the checklist for whether the tool is valid or not will be a determining factor in the validity test analysis process. Analysis of the Management Quality Acceptance Test in the form of a questionnaire totaling fifteen questions with a scoring system from 1 to 4. One is the lowest score and four is the highest score. List of 49 acceptance test questions. To fulfill the requirements for a valid and reliable questionnaire instrument, 15 questions with 40 respondents as indicators were checked, finding that the calculated r-value must be $\geq$ r-table at $\alpha = 0.312$ and the average Cronbach's alpha value must be > 0.312. Analyze data before and after the intervention to determine whether the system or intervention meets acceptance criteria and whether improvements or changes have occurred. Statistical analysis will be carried out to compare data before and after intervention. The data obtained was then subjected to the Shapiro-Wilk normality test to determine whether the data obtained was normal or not. If the distribution of the data is declared normal, then continue using the Paired Sample T-test to determine whether there are significant differences between the two data sets. If the p-value is > 0.05, then there is no difference between the quality of management of patient transfer activities before and after the patient scanner table is designed, while the p-value < 0.05 means there is a difference between the quality of management of patient transfer activities before and after the patient scanner table is designed.

RESULTS AND DISCUSSION

The Rapid Entire Body Assessment (REBA) Validation Test

The REBA validation test was carried out by giving radiation oncologists, Facility Management Service officers, senior radiotherapy radiographers, occupational safety and health officers, and ergonomists a functional test sheet containing questions regarding Functionality (function), Reliability (reliability), Usability (ease of use), Efficiency (efficiency), Maintainability (ease of maintenance), and Portability (ease of moving).

Table 1 presents the results of validation tests by expert validators regarding the design of a table as a patient moving tool. This test is carried out using 16 questions which cover various important indicators, namely Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability. Five experts were invited to carry out validation by providing assessments using a scale of 0 (invalid) and 1 (valid). The assessment results from the five experts showed that overall, the design of the table as a patient transfer tool was declared 100% valid. Each question and indicator received a valid score from all experts who participated in this test. The results of the success of the design are also shown in Figure 2, the adjustment process when used on the CT simulator.

Table 1. Expert Validation Assessment Results

Question	Number of Validators	Value (%)	Information
Functionality			
The brachytherapy patient transfer table functions well	5	100	Valid
The brachytherapy patient transfer table can be applied to the simulator table	5	100	Valid
The brachytherapy patient transfer table is safe to use for patients	5	100	Valid
The process of transferring patients using the transfer table went smoothly	5	100	Valid
The brachytherapy patient transfer table meets the expected standards and needs	5	100	Valid
Reliability			
The brachytherapy patient transfer table did not malfunction	5	100	Valid
The brachytherapy patient transfer table can reduce the occurrence of human error	5	100	Valid
Usability			
How a brachytherapy patient transfer table works is easy to understand	5	100	Valid
How a brachytherapy patient transfer table works is easy to learn	5	100	Valid
The way the brachytherapy patient transfer table works is easy to operate	5	100	Valid

Efficiency			
The brachytherapy patient transfer table speeds up the patient transfer process	5	100	Valid
Maintainability			
The brachytherapy patient transfer table is easy to modify	5	100	Valid
The process of moving patients with a moving table can be carried out stably	5	100	Valid
The functionality of the moving table is well-tested	5	100	Valid
Portability			
The brachytherapy transfer table can be used by all healthcare workers	5	100	Valid
Brachytherapy transfer tables can replace previous manual systems	5	100	Valid

Based on the assessment of the REBA test before and after using the brachytherapy patient transfer table by the validator, the average REBA test result before using the brachytherapy patient transfer table was 11.6, which is included in the Very High-Risk category and changes are very necessary (29). The main goal of this change is to reduce the risk of injury and increase safety and comfort for patients and healthcare workers during the transfer process. Based on research by Imran Aslam et al. improvements in existing technology can reduce the risk of injury to workers in the patient transfer process (30). After retesting the ergonomic value of the patient transfer system using the brachytherapy patient transfer table, the average REBA test value was 2.8. The REBA test value after using the moving table changed to the Low-Risk category (29). Overall, these REBA test results provide important information that although the new patient transfer table shows good validity in terms of functionality, ergonomic improvements are still needed to ensure that this tool can be used safely and effectively in a clinical context.

Figure 2. Adjustment process with CT simulator

The assessment results from the five experts showed that the aspects of Functionality (function), Reliability (reliability), Usability (ease of use), Efficiency (efficiency), Maintainability (ease of maintenance), and Portability (ease of moving), the design of the table as a tool for moving patients were rated 100 % valid. Each question and indicator received a valid assessment from all experts who participated in this test. This perfect validation confirms that the table meets all the established criteria, in terms of functionality, reliability, ease of use, efficiency, maintenance, and patient transfer. With these excellent validation results, the design of the patient transfer table can be continued to the next testing stage as a final product. Validation from experts ensures that this table is ready for use in medical practice, providing confidence that this tool will function optimally and meet the needs of moving patients during brachytherapy procedures.

Management questionnaire test

Acceptance tests were carried out before and after designing the table as a patient-moving tool by radiotherapists, nurses, medical physicists, radiation oncologists, medical physicist residencies, and fieldwork practice students. To fulfill the requirements for a valid and reliable questionnaire instrument, 15 questions with 40 respondents as indicators were checked, finding that the calculated r-value must be ≥ r table at $\alpha = 0.312$ and the average Cronbach's alpha value must be > 0.312. Based on the results of the validity test using the Pearson correlation 87 test, an average r-count value of 0.444 ≥ r-table at $\alpha = 0.312$ was obtained. Meanwhile, the Cronbach's alpha value, namely 0.480, is > 0.312 which is reliable, so it can be concluded that the questionnaire instrument has met the validity and reliability requirements as a suitable data collection tool to be used to measure all aspects of the variables in this research design.

Table 2. Statistical Test Results

Condition	Mean ± Standard deviation	P-value	
		Shapiro-wilk	Paired t-test
Pre-test	22.55 ± 1.83	0.132	0.00
Post-test	54.63 ± 3.22	0.079	

Table 2. Testing for differences in conditions was carried out using the Paired T-Test method. As an initial requirement, a normality test was carried out on the data with the Shapiro-Wilk reference. The normality test results show that the significance value in the Pre-Test is 0.132 and in the Post-Test is 0.079, both of which are above the p-value of 0.05. This shows that the data is normally

distributed. The next step is the data homogeneity test, which produces a significance value of 0.001, smaller than 0.05. These results indicate that the data is homogeneous. By fulfilling the requirements for normality and homogeneity, the Independent Samples Test can be carried out. The test results show a significance value of 0.000, which is smaller than 0.05, indicating that there is a significant difference between conditions before and after designing the table as a patient-moving tool.

Overall, this analysis indicates that designing a table as a tool for transferring patients in brachytherapy procedures has succeeded in increasing the ergonomic value for health workers, improving the quality of treatment for transferring cervical cancer brachytherapy patients, as well as increasing the efficiency and effectiveness of the patient transfer process. This shows that the innovation has had a significant positive impact on medical practice regarding brachytherapy. This is in line with research by Imran et al. adequate design of patient transfer equipment will reduce the risk of injury to healthcare workers (30). Kristen L et al. The research also emphasized that mechanical patient transfer devices are more effective and safer in reducing the risk of injury for health workers compared to manual patient transfer processes (17). The patient transfer process now only requires two health workers to operate the transfer table, in contrast to previously which required at 6-7 medical staff to move a patient.

This research implies that it has proven the effectiveness of the design of the brachytherapy patient transfer table so that it can be used as a brachytherapy patient transfer tool that better accommodates the needs of both staff and 102 patients. The use of this moving table allows it to be used in the future for MRCCC Siloam Hospitals Semanggi. This table is used from the procedure room to the applicator removal process.

CONCLUSION

Based on research regarding the design of the brachytherapy transfer table, it can be concluded that the results of functional tests carried out by radiation oncologists, Facility Management Service officers, senior radiotherapy radiographers, occupational safety and health officers and ergonomists on the design of the brachytherapy patient transfer table have been proven to function effectively. effective and efficient and meets the conformity standards that have been created. The design of the brachytherapy patient transfer table was declared valid in terms of Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability by the five validators who tested the transfer table. the patient. This can be seen from the 16 questions that passed the valid criteria so that the design of the brachytherapy patient transfer table was considered 100% valid. The design of the

brachytherapy patient transfer table was assessed as effective based on an acceptance test for the management of the brachytherapy procedure using a transfer table in replacing the old method of patient transfer system based on test results which showed a significance value of 0.000, which is smaller than 0.05, indicating a significant difference between before and after conditions. patient transfer table design. This analysis also shows that patient transfer tables for brachytherapy successfully improve ergonomics for healthcare workers, improve the quality of cervical cancer patient transfers, and increase the efficiency and effectiveness of the process, providing a significant positive impact on the medical practice of brachytherapy.

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