SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

This study sought to gain insight into future OR layouts through a series of surgical workflows representing typical surgical procedures.

Process Simulation During the Design Process Makes the Difference: Process Simulations Applied to a Traditional Design

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Key Concepts/Context

Minimal evidence exists regarding the design implications of using process simulation to assist in the process of designing new operating room (OR) layouts. While the traditional design process for OR layout does incorporate the experiences and insights of users, functionality testing of the OR environment is usually conducted post occupancy. Utilizing process simulation during the design process allows users to experience simulated layouts and evaluate functionality and efficiency of proposed designs prior to the investment in construction.

Methods

For this case study, four simulations were conducted with separate surgical teams in an environment that possessed the same spatial characteristics as the new OR design. The following four typical procedures were chosen for the simulations: (1) trauma (hip), (2) Da Vinci surgical robot, (3) trepanation (brain surgery using microscope), and (4) orthopedic (knee/hip/laparoscopy). Surgical teams were comprised of surgeons, anesthetists, and instrument staff who had worked together previously on the intervention being simulated. In the OR a mock-up of the supply bridge was constructed. The mock-up was height adjustable and able to be freely moved around in the OR. Moveable symbols were placed on the supply bridge to determine the desired location for the various connections.

Data collection was conducted by four researchers, using the staged-world observations method, which captured in detail (1) observable activities and verbalizations, and (2) self-report data about how the new physical layout supported performance. One of the four observers was a human factors expert that led the simulation, allocating appropriate time for both simulation and discussion.

Prior to the simulation, the four observers were given a form on which to record their observations. The form contained the initial layout and the boundaries of the clean area. During the simulations, observers recorded conflicts that arose due to spatial parameters. Conflicts were recorded based upon where they occurred spatially and the phase (preparation, operation, completion) in which they occurred. Simulations were also videotaped for reference during the evaluation period.

Following the simulation the forms were collected and evaluated. Once the forms were evaluated the surgical teams discussed the observations with the researchers. If a conclusion was drawn with consensus between the surgical team members, the process simulation was ended. However, if consensus was not reached, positioning of the equipment within the room was adjusted to see if the changes suggested by surgical team members led to a more workable solution.

Findings

Five The simulations in this study revealed that a 3.0 x 3.0 m^2 large clean area positioned under a unidirectional down-flow plenum is large enough to accommodate all of the surgical team and surgical instruments required for the specific intervention while satisfactorily positioning the patient. However, these results require the use of a moveable operation table. It was also revealed through the simulations that a multi-trauma requiring more than one surgical team to operate simultaneously would not be able to fit within the 3.0 x 3.0 m^2 clean area tested.

The simulations also revealed that due to the larger space of the OR room, necessary space requirements for movement of the C-arm, and optimal positioning of anesthesia staff with their required equipment, a centrally located clean area with the associated unidirectional down-flow plenum was not optimal. It was decided that the remaining space within the OR was best utilized being positioned together near the corridor side of the OR rather than being positioned equally around the clean area.

The classic positioning of the anesthesia section was also assessed. During the simulations observers noted that moving the position of the anesthesia section near the side of the OR helped to alleviate risks associated with transporting and maneuvering the patient bed into position beside the OR table. By relocating the anesthesia section, greater access to the clean area was achieved for the patient, instruments, and equipment.

When simulating procedures using the Da Vinci surgical robot, the scenarios revealed several conflicts regarding the height of the supply bridge. Typically, sterile covers are placed on the robot's arms and the arms are extended to their highest position prior to positioning it into the clean area. With the supply bridge at a lower height, it is impossible to position the robot in this manner. However, due to minimal tables, staff, and instruments within the clean area during that procedure, it

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is possible to extend the arms of the robot to their full height after it has been positioned over the patient. The scenarios within the simulation also revealed conflicts with positioning the microscope, procedures involving an operation helmet, and accessibility for making connections. Taking into consideration the conflicts that arose during the simulation, it was determined that a 2.05 m height for the supply bridge is adequate for most procedures. Due to this decision, future microscopes will need to be purchased with specific dimensions to minimize conflicts, moveable stools will be made available for shorter staff members, taller surgeons wearing an operating helmet will need to bend down moving in and out of the clean area, and a new protocol for moving the robot into place will need to be observed.

Additional benefits from running the simulations were the objectivization of participants' thoughts, additional support for the new design during and following the process, spatial mapping of the process, and determination of required areas and line of sight.

Design Implications

While conducting simulations is more costly and time consuming than conventional methods, the insights gained through the simulations provided valuable information that significantly directed the design of the new OR rooms. Findings from this research suggest that placement of the clean area and anesthesia section can be moved to produce greater flexibility with fewer conflicts. Findings also suggest that process simulations should take place early in the design process to accommodate necessary changes derived from the findings. When considering the use of simulations during the design process, it is also necessary to consider success factors such as the ability to move variables being studied throughout the simulation, connecting as many actions as possible during a scenario to allow people to act naturally, offering space after a partial session for discussion, and creating the most realistic simulation possible.

Limitations

Limitations to this study are that current workflows were used to simulate future designs. While this assisted in creating cohesiveness among the team members, deeper insights could have been observed if time had been permitted to train the teams on new workflow processes. Another limitation to this study is that conducting simulations is more costly and time consuming than conventional methods.