Surg Endosc (2001) 15: 1140–1143
DOI: 10.1007/s004640080092

Surgical Endoscopy
Ultrasound and
Interventional Techniques

Dedicated minimally invasive surgery suites increase operating room efficiency

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Received: 22 June 2000 /Accepted in final form: 1 November 2000/Online publication: 5 July 2001

Abstract
Background: The rapid adoption of laparoscopic surgery since the late 1980s added tremendous complexity into the operating room (OR) environment. For each case, a plethora of additional equipment—including monitors, video equipment, wiring, tubing, and cords—had to be set up, prolonging OR turnover time and decreasing OR efficiency. In 1993, the concept of designated minimally invasive surgery (MIS) suites was introduced. MIS suites integrated monitors and video equipment into the OR on ceiling-mounted columns and moved the controls to a centralized nursing station. The overall effect of this innovation on OR efficiency has not been measured.
Methods: Five RNs with varying degrees of MIS experience were instructed on video setup and put-away criteria and then timed while performing a set of standardized tasks. Each set of tasks was performed twice using a standardized surgery model. Differences in setup and put-away times between MIS suites and standard ORs were tested using the *t*-test for paired comparisons.
Results: The mean ± standard deviation (SD) video setup times were 27.9 ± 5.3 sec (MIS) and 254.3 ± 54.0 sec (standard); the put-away times were 19.8 ± 2.7 sec (MIS) and 222.3 ± 26.0 sec (standard). The mean difference ± standard error (SE) in both the setup (226.4 ± 16.9 sec, $p = 0.0001$) and put-away times (202.5 ± 8.6, $p = 0.0001$) were large and statistically significant.
Conclusion: Using a simulation model, we have demonstrated that the use of a MIS suite reduces video setup and put-away time significantly, with the potential for significant associated cost savings. This provides just one justification for the high cost of building such "ORs of the future."

Key words: Laparoscopy — Operating room — Minimally invasive surgery — Minimally invasive surgery suite — Endosuite — Efficiency — Costs

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The expansion of minimally invasive surgery (MIS) in the 1990s, especially the introduction of video laparoscopy, has led to the rapid introduction of an entirely new generation of equipment into traditional operating rooms (ORs). The uncontrolled proliferation of monitors, cables, tubing, and other equipment housed on large wheeled carts frequently overwhelmed small operating suites that were not designed to accommodate these new technologies. This can result in operative inefficiencies and safety problems for patients and staff [1]. In an effort to address this problem, we designed the first of a series of MIS suites in 1993. MIS suites integrate systems such as power, insufflation gas, and video connections through central channels. Monitors and devices such as insufflators, light sources, and electrosurgical generators are moved from mobile carts onto ceiling-mounted columns. As many controls as possible are moved to a remote nursing "control station." MIS suites are intended to reduce OR clutter, increase safety, prevent technical problems, improve the comfort of the OR staff, and enhance the efficiency of the preparation and dismantling of equipment between cases [2]. These innovations may also improve the safety of more complex laparoscopic procedures.

Although many MIS suites have been constructed over the past 7 years and are currently being actively marketed to hospitals by industry [4, 5], the actual effect of this innovation on OR function has not been measured. We used a simulation model to compare the efficiency of a standard OR to an MIS suite in terms of setup and takedown of video equipment.

Materials and methods

Description of ORs

Standard ORs at the study site (Legacy Emanuel Hospital, Portland, OR, USA) are 26′ × 26′. For this experiment, a "generic" OR was selected based on its central location relative to where traditional video equipment stacks are stored. The MIS suite at our institution, is a 22′ × 24′ specifically designated video OR. Three ceiling-based arms or columns are strategi-

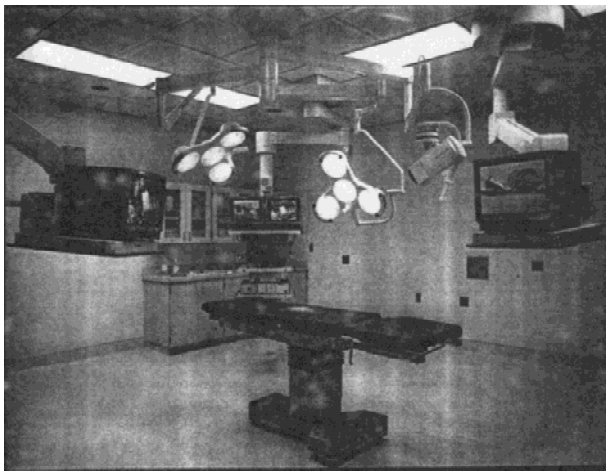

Fig. 1. An MIS suite.

cally placed to hold monitors and equipment. The design took into consideration economy of movement, especially for the nursing staff, while providing surgeons with close, ergonomically advantageous monitor placement around the OR table. The main column is positioned on the patient's left. It can support ≤485 lb and contains two 13″ monitors, two cameras, two light sources, an insufflator, and an electrosurgical unit. Two additional columns support large-screen monitors that can be positioned at either the head or foot of the OR table (Fig. 1).

Study subjects

Five RNs with varying degrees of MIS experience were recruited to participate in the study. RNs were chosen over surgical technicians and operating room assistants since they are generally responsible for the setup of video equipment prior to each case.

Tasks

We were interested in comparing the amount of time required to set up and put away video equipment in the standard OR compared to a MISS. These tasks represent a large component of turnover time for laparoscopic cases at our hospital. The study subjects were briefed on the specific tasks required to perform the video setup and put-away procedures. For the standard OR, the 'setup' involved wheeling the main and slave video carts from the storage area to the OR and placing them in appropriate locations for a laparoscopic foregut procedure (e.g., laparoscopic cholecystectomy) (Fig. 2). Once the carts were in place, the power supply was plugged into an electrical outlet, the video equipment was turned on, and the two monitors were connected by coaxial cable. The task was complete when color bars were seen on both monitors. Put-away criteria for the standard OR involved a reversal of these steps and ended when both the master and slave carts were returned to the storage area. Setup criteria for the MIS suite involved switching on all video equipment and achieving the color bar test pattern on the monitors. Put-away criteria for the MIS suite involved switching off the video equipment and pushing the monitors up to the ceiling.

All RNs were instructed not to race, but to set up the equipment as they would if preparing for a routinely scheduled case. Each set of tasks was performed twice. All tasks were timed by one person using an electronic stopwatch.

Statistical analysis

Estimates of the time required to perform each task were expressed in terms of mean and standard deviation (SD). Mean differences in setup and put-away times between MIS suites and standard ORs were tested using the *t*-test for paired comparisons.

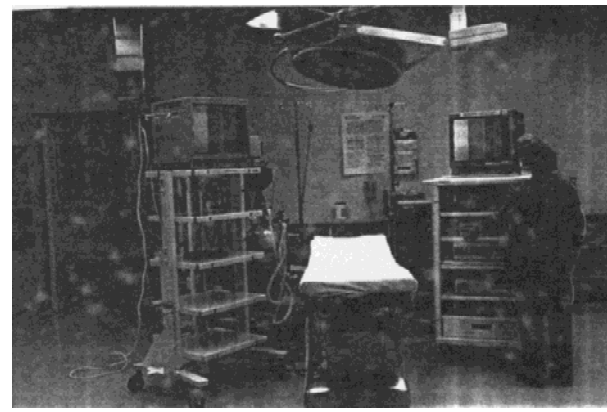

Fig. 2. Floor plan of a traditional OR set up for laparoscopic cholecystectomy.

Results

Five study sets were completed. Each study set included the setup and put-away of video equipment in the traditional OR and the MIS suite. Protocol deviations occurred in the traditional OR. Two RNs asked to review how to connect the main video cart to the slave cart with the coaxial cable and to confirm which line was in use prior to the task. One RN, while performing the setup task, had difficulty plugging in the coaxial cable. One RN took two main video carts instead of a main cart and a slave cart, which resulted in not having a coaxial cable to connect. A second subject went to retrieve the cable off the slave cart in the storage area, which added 1 min to her time. Although the RNs were specifically instructed not to race, one participant was noted to be running during her tasks; however, she later explained that this was her usual speed. Two RNs tossed the video cable across the room in a manner that would be extremely hard on the equipment in a real situation. No protocol deviations occurred during the MIS suite tasks.

The mean video setup times were 27.9 secs (±5.3) for the MIS suite and 254.3 secs (±54.0) for the standard suite. The put-away times were 19.8 secs (±2.7) for the MIS suite and 222.3 secs (±26.0) for the standard OR (Fig. 3). The mean difference in the setup time was 226.4 secs (standard error (SE) 16.9, $p = 0.0001$); and the mean difference in the put-away time was 202.5 secs (SE 8.6, $p = 0.0001$) (Fig. 4).

Discussion

Using a simulation model to evaluate the time required to set up and dismantle video equipment for video-assisted surgery, we found that the use of a minimally invasive surgery suite was associated with a decrease of ~3–4 mins in performing these procedures compared to a standard OR.

The explosion of laparoscopic surgery in the late 1980s added tremendous complexity to the OR environment. Laparoscopic procedures introduced surgeons to a whole array of equipment that had previously been absent from the OR [1]. Suddenly, large heavy carts containing video equipment—including monitors, cameras, light sources, carbon dioxide insufflators, and documentation devices such as videocassette recorders and printers—were wheeled into

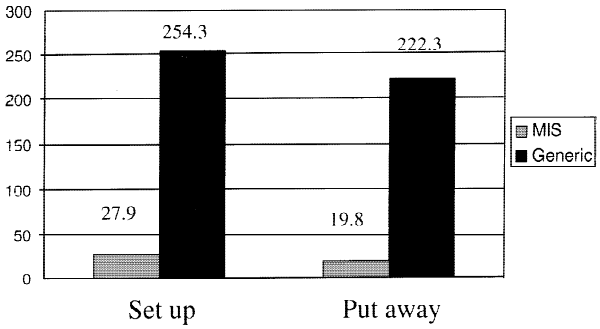

Fig. 3. Mean video setup and put-away times (in seconds) for a generic OR and an MIS suite.

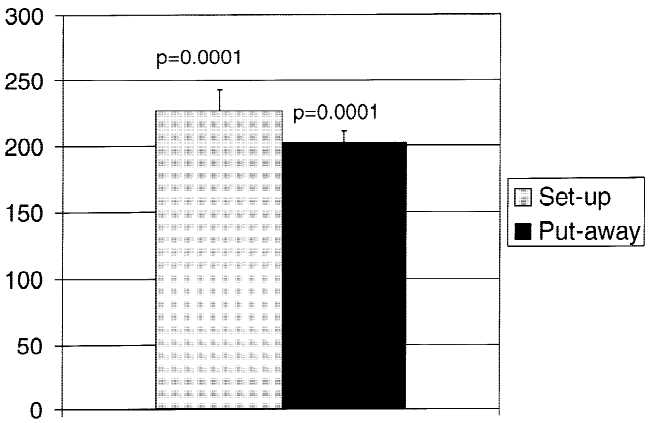

Fig. 4. Mean difference in video setup and put-away times (in seconds) between a generic OR and an MIS suite.

ORs. The performance of more complex procedures required the addition of a slave cart, which contained an additional monitor with a coaxial video connection to the laparoscopic camera. The usual result was a tangle of delicate wiring, electrical cords, foot pedals, and suction and irrigation tubing that was draped haphazardly in and around the surgical field. Cables were subject to damage from foot traffic and the movement of carts and patient stretchers. The carts created a large footprint, interfering with movement around the OR and obstructing access to the patient.

Problems with this ad hoc approach to outfitting an OR for laparoscopic procedures quickly became apparent. The inability to place video monitors in the direct sight line of surgeons and OR personnel is known to increase fatigue [3] and also has the potential to increase surgical errors. If emergencies should arise, access to the patient by the anesthesiologist and OR staff is suboptimal. Patient safety may be further compromised because equipment controls are frequently near the sterile field, making it difficult for the nursing staff to access controls in a timely and sterile manner. Traveling video carts require extra time to set up at the start of a case and require frequent troubleshooting. Standard carts are also heavy and awkward to move, which may lead to injury to OR personnel. Finally, the time spent setting up for routine video procedures affects the flow of the OR schedule and adds to the turnover time, decreasing overall OR efficiency.

In an attempt to address this problem, we developed the concept of surgical suites specifically designed for performing minimally invasive procedures. The MIS OR concept first emerged in the early 1990s [5, 7]. The initial endosuite was essentially a traditional OR outfitted with a cartlike structure suspended from the ceiling. Nevertheless, it was considered to be a breakthrough in design.

The MIS suite concept has several critical design elements. Integrating the monitors and other video-assisted surgical equipment on three ceiling-mounted columns from the ceiling eliminated heavy instrument carts. The main column supports two independent video systems; monitors; an insufflation, suction and irrigation system; and cautery devices. The secondary video systems provide a backup system and allow dual viewing of concurrent video procedures (such as simultaneous choledochoscopy and laparoscopy, or thoracoscopy and laparoscopy). Columns that allow vertical and horizontal movement support the accessory monitors, permitting comfortable viewing around the surgical field (Fig. 1). Restricting documentation equipment and other controls to the circulating nurse's control station allow it to be removed from the surgical field.

Other investigators have reported on various advantages of MIS suites [6], but this is the first study that we know of that has tried to quantify the time saving that can result from using an MIS suite. Although this experiment simulated the process of OR preparation instead of measuring times from actual cases, we believe that our findings are valid. We approached the assessment of task times in a systematic manner, to minimize the effect of variations in the myriad other factors that would impact efficiency in a real-world situation. All tasks were performed on the same day by the same subjects and were timed by the same investigator. A single person instructed all subjects in the task components.

There are some limitations to this study that may affect how our findings are interpreted. Because we used a simulation, the time savings we measured may not be directly translatable into the occurrences in a typical OR day. Because a conventional OR may be used for several MIS procedures in a row, there may not be a large number of video setup and put-away procedures over the course of the day since the equipment could possibly stay in the room. Although all study participants were cautioned to perform the tasks in their usual fashion, they may have modified their activities so that the procedure times were not representative of usual practice. The study subjects knew that their tasks were being timed, but they were not explicitly told that the object of the experiment was to compare the setup and put-away times between the two types of suites.

The era of minimally invasive surgery has introduced a new gold standard for many surgical procedures traditionally performed via an open approach. The possibility of increased costs due to new technology and OR inefficiency is of concern. Like other structures and processes involved in delivering MIS services, OR suite design will also have to adapt to the demands of changing technologies. We believe that MIS suites will become the new gold standard for operating rooms supporting video-guided surgery. This study has demonstrated that MIS suites can reduce video setup and put-away times significantly. The potential for significant associated cost savings, improved staffing productivity, and increasing OR efficiency provides just one justification for building these "ORs of the future."

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