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# Efficacy of Medical Operations and Layout Planning Onboard Nontraditional US Navy Vessels at High Seas

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**ABSTRACT** Introduction: Attempting to expedite delivery of care to wounded war fighters, this study aimed to quantify the ability of medical and surgical teams to perform lifesaving damage control and resuscitation procedures aboard nontraditional US Navy Vessels on high seas. Specifically, it looked at the ability of the teams to perform procedures in shipboard operating and emergency rooms by analyzing motion of personnel during the procedures. Methods: One hundred and twelve damage control and resuscitation procedures were performed during a voyage of the US Naval Ship Brunswick in transit from Norfolk, Virginia, to San Diego, California. The ability of personnel to perform these procedures was quantified by the use of motion link analysis designed to track the movement of each participant as they completed their assigned tasks. Results: The link analysis showed no significant change in the number of movements of participants from the beginning to the end of the study. However, there was a learning effect observed during the study, with teams completing tasks faster at the end of the study than at the beginning. Conclusion: This shows that the working conditions aboard the US Naval Ship Brunswick were satisfactory for the assigned tasks, indicating that these medical operations may be feasible aboard nontraditional US Navy vessels.

## INTRODUCTION

In June 2009, Secretary of Defense Robert M. Gates implemented policy in the US Military requiring that combat casualties arrive at a treatment facility within 60 minutes of the call for casualty evacuation[1] instead of the previous standard of 2 hours.[2] Adherence to the so-called "Golden Hour," along with improved treatment capabilities, has likely contributed to improved casualty survival that has been observed in the last 10 years.[1] During conflicts in Iraq and Afghanistan, combat casualty care evolved further to involve a series of stages or "roles," aimed again at improving survival and decreasing the time that it takes for a combat casualty to receive care.[3,4] This system involves on scene stabilization of casualties as role one. The patient is then evacuated using casualty evacuation to a role two treatment facility. Both fixed and mobile facilities have been used to fill role two care responsibilities of resuscitation and immediate surgical stabilization. When the patient is stable enough for further treatment (ideally within 4–8 hours of arrival at the role 2), medical evacuation is used to transport casualties to a role three facility equipped with intensive care units and an increased range of surgical specialties. From there, patients will be transported to a role four facility in the United States as the definitive care facility[3] (Appendix S1). In an effort to continue to decrease the amount of time that it takes to deliver care to wounded war-fighters, this study explored a novel method of delivering role two care in a combat setting.

Traditional US Navy vessels designed for surgical and resuscitative role two medical operations are not capable of sailing swiftly to combat zones. This increases the time between the point of injury and delivery of care for wounded soldiers. More agile US Navy vessels, not originally designed to perform medical missions, are capable of deploying into littoral spaces and rapidly provide damage control and acute care surgeries to wounded war-fighters. The goal of this project is to outfit smaller Navy ships with Capabilities-Based Modular Treatment Facilities (CB MTF), modules designed to be installed on ships when they are needed and taken off or stored when they are not needed.

These smaller, nontraditional vessels experience unique challenges, which do not exist on larger Navy vessels. These challenges include magnified deck accelerations in high sea environments, smaller work spaces, and complications of transporting patients to and around the ship itself. Other obstacles include finding a suitable layout for emergency rooms (ERs) and operating rooms (ORs), engineering ways to adequately anchor X-ray machines, operating tables, anesthesia carts, and other operative equipment. With these challenges, it was hypothesized that the ability of medical and

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**TABLE I.** North American Trade Organization (NATO) Sea State and Corresponding Wave Height

| NATO Sea State | Wave Height (Meters) |
|---|---|
| 0–1 | 0–0.1 |
| 2 | 0.1–0.5 |
| 3 | 0.5–1.25 |
| 4 | 1.25–2.5 |
| 5 | 2.5–4.0 |
| 6 | 4.0–6.0 |
| 7 | 6.0–9.0 |
| 8 | 9.0–14.0 |
| >8 | >14 |

surgical personnel to perform their job functions within the CB MTF will be adversely affected. This project looked specifically at how the shipboard operating and ERs effected the way test subjects moved within them to perform their jobs. With this specific aim, it is hypothesized that experience aboard the ship will cause improvement in the efficiency of the participants' movements as they complete their assigned tasks.

This specific study was a part of a major three-phase investigation entitled "Effect of High Deck Accelerations on Surgical Tasks" funded by the following organizations for each phase: Phase I—Office of Naval Research, Phase II—Office of the Chief of Naval Operations (OPNAV) N81, and Phase III—Advanced Medical Development and OPNAV N81. Phases I and II were laboratory-based studies completed using a motion simulator platform, which was designed to recreate specific shipboard motions.[5] The motion of the platform was programmed based on accelerometer data collected from voyages of the US Ship Freedom (Littoral Combat Ship [LCS]-1) and the US Naval Ship (USNS) Spearhead (Expeditionary Fast Transport [EFT]-1) (Appendix S2). Participants were asked to perform surgical and resuscitation tasks while on the motion platform, which recreated ship motion up to North Atlantic Treaty Organization (NATO) sea state 4 (Table I). Phase III was completed aboard the USNS Brunswick (EFT-6), a Spearhead class vessel, during a voyage between Joint Expeditionary Base Little Creek-Fort Story, Virginia and Naval Base San Diego, California from 30 January to 14 February, 2017.

## METHODS

The test protocol, "Effect of High Deck Accelerations on Surgical Tasks Phase III Test Execution Plan," PID Number: 1290, Bureau of Medicine and Surgery Number: NSWCPC.2016.0001, Revision September 2016/3.0, was written by the NSWC PCD Principal Investigator, then reviewed and concurred by Naval Postgraduate School, the two sponsoring agencies, the senior surgical Subject matter experts (SME), and Operational Medicine and Capabilities Development Bureau of Medicine and Surgery Program Office. It received Institutional Review Board review by Navy Experimental Diving Unit in Panama City, Florida.

The USNS Brunswick is the sixth Spearhead-class EFT in service with the Military Sealift Command. The EFT program is tasked with building a high-speed, shallow draft vessel intended for rapid intratheater transport of medium-sized cargo payloads. The Brunswick is 337 ft, 11 in. long and 93 ft, 6 in. at beam, with a draft of 12 ft, 7 in. (Appendix S3). The USNS Brunswick is capable of 43 knots; however, during the study, the typical cruising speed was between 14.5 and 16 knots. This ship was selected for this study for the following reasons:

1) The USNS Brunswick represents a new, small class of high-speed ship, potentially capable of quickly transporting the CB MTF, or similar modular, scalable role two surgical facilities capable of closing the distance between injury and care, and conducting operations within the littoral zone.
2) This ship represents one of the classes of high-speed ship represented by motion profiles used in the Phases I and II Effect of High Deck Accelerations on Surgical Tasks studies.
3) The ship's sail plan took it to geographic locations (off Cape Hatteras and along the Baja Peninsula) in early February 2017, which historically provided the best opportunity to replicate the sea state 4 conditions tested in Phase II.

The USNS Brunswick's course was also chosen so that the crew and medical personnel would experience sea states similar to those experienced by the USNS Spearhead, as well as to encounter a variety of sea states as would be encountered on a typical voyage. The time of year for the voyage was chosen to again attempt to match the sea states experienced by the USNS Spearhead on its voyage and consequently the "voyages" of the motion platform. Not only were the sea state conditions chosen to mirror what was encountered on the motion platform but they were also chosen to simulate a "worst case scenario" experience for those aboard the USNS Brunswick. This idea was incorporated into many other facets of the experimental design of this study, including placement of the modular OR and ER, as well as the orientations of components of the rooms within the rooms themselves. This was done so that success on this voyage could accurately be extrapolated to predict success on voyages, which had conditions more ideal than the voyage of the USNS Brunswick.

The USNS Brunswick, its crew, and study participants experienced variable NATO Scale sea states during the voyage. Sea conditions met or exceeded expectations with 20 (18%) of the operations occurring in NATO sea state 3 and 48 (43%) in sea state 4. Procedures were performed at a maximum of NATO sea state 4 because any sea state above 4 will prevent a transport helicopter from landing on an LCS type ship.

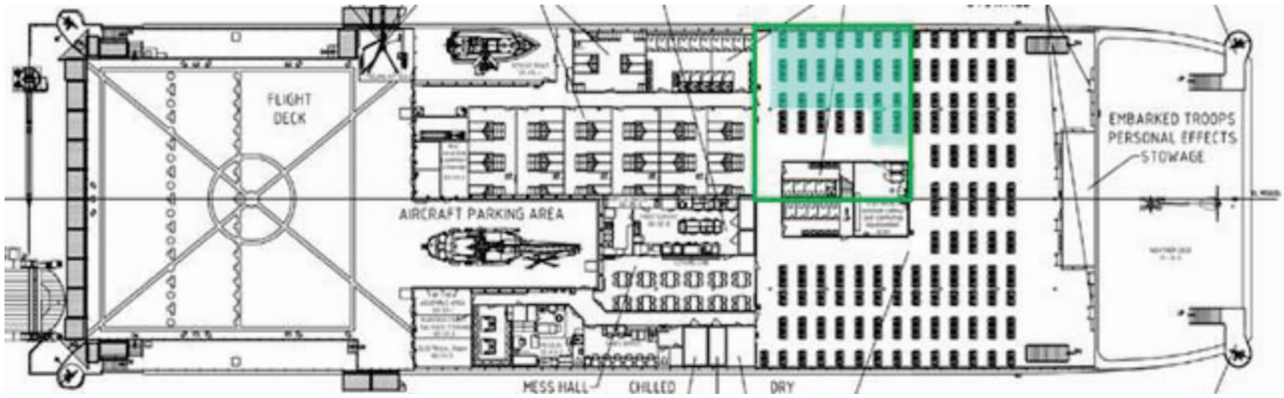


**FIGURE 1.** Schematic diagram of the USNS brunswick specifically of the deck that was used for the study. The area highlighted in *green* is the area that was occupied by the CB MTF.

A modular OR and ER were chosen so that they could be deployed on many different sea frames, and on many different missions, increasing their versatility and ability to provide care whenever and wherever needed. That said, the modules can be deployed in many different places onboard a ship such as the USNS Brunswick, which has a large, versatile transport bay area. The researchers chose the position of the module based on the place, which experienced the largest deck accelerations seen by the accelerometers on the USNS Spearhead (Fig. 1). This meant that the test teams in the study experienced the most vertical translation possible on that particular deck of the USNS Brunswick. Translation movements were measured by accelerometers worn by each individual, as well as units mounted to the ship. This was done so that researchers could accurately say that if the resuscitation and damage control procedures were feasible on this part of the ship, they would be feasible on any part of the ship. They also gave the patient bed and operating table a "worst case scenario" orientation within the module itself, due to the possibility of the module being loaded in different ways on the ship. The basis for them choosing to have the patient perpendicular to the direction the ship was traveling comes from admittedly anecdotal evidence. Experienced sailors asserted that participants would experience more difficult accelerations in this orientation on the ship (Fig. 2).

Two surgical teams, Red and Blue, each consisting of a randomly assigned General Surgeon (who served as the team lead), Certified Registered Nurse Anesthetist (CRNA), Perioperative Nurse, Corpsman, and two Surgical Technologists provided resuscitation and damage control surgery to surgical mannequins simulating improvised explosive device blast injuries. In all, 112 procedures were performed during the 12 work days of the 16-day voyage. On each of the work days, two or three 4-hour test blocks were conducted for a total of 8 or 12 patients for each day. Three consecutive eight-patient days were originally scheduled at the beginning of each week, the focus being on replication of the Phase II study schedule. The remaining days each week were initially scheduled as 12-hour days, approximating medical watch rotations required to sustain 24-hour operations.

Given the importance of testing under suitable seaway conditions, when the ship encountered SS4 on record test day 3 (2 FEB), it was decided to move up the third 4-hour block that otherwise would have been conducted on 4 FEB. Similarly, when calm (SS2) conditions were encountered on what had been scheduled to be a 12-hour day (10 FEB), it was decided to reserve the materials needed for that day's final 4-hour block and add an additional four patients to the end of the week (12 FEB) when the forecast predicted higher sea states. Decisions to cancel procedures and reschedule them for different days were made by the SME, as well as the principle investigator of the study. None of the tasks were canceled because of dangerous circumstance or equipment malfunction.

The two teams were provided with a modular type ER and OR, where they were tasked to complete treatment procedures on modified cut suit surgical mannequins. A third team, the White team, had its own randomly assigned Surgeon, CRNA, and Surgical Tech to serve as backup personnel should a participant be sick or otherwise unable to perform their duties for the day. It is acknowledged that it is extremely rare to have backup personnel during a typical mission; however, the decision was made to have the additional personnel in order to ensure our ability to collect enough data, during our limited time aboard the USNS Brunswick. Each day, the Red and Blue teams were assigned to either the OR or ER for the day and were switched the next day to be in the other room. This flipping back and forth continued for 1 week until the teams were randomly reassigned during transit of the Panama Canal. After the teams were reassigned, they were again assigned to switch back and forth between the OR and the ER until the completion of the voyage in San Diego on February 14, 2017.

Since medical personnel on deployment will normally be permitted to take medications as needed to alleviate motion sickness, as well as consume tobacco and caffeine products, it was decided that preventing them from doing so would

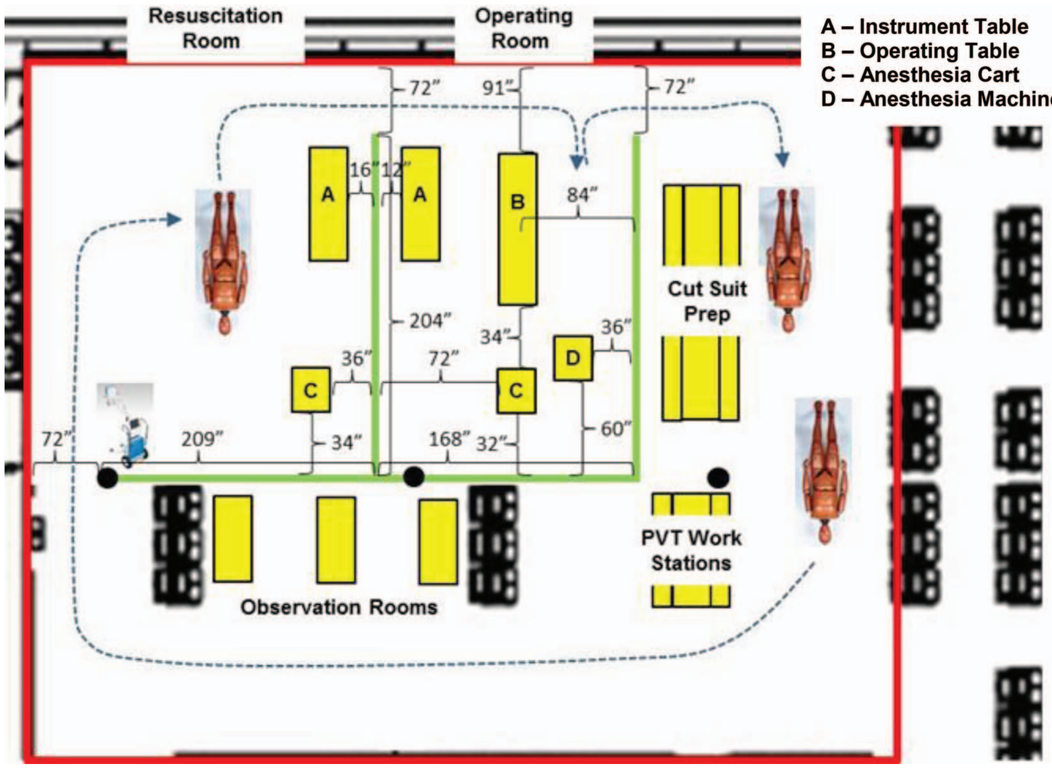


**FIGURE 2.** Shipboard test area, as configured for study. This diagram is the enlarged version of what is highlighted in *green* in Figure 4. The bow of the ship is to the right of this diagram, making the patient orientation perpendicular to the direction the ship is traveling.

create artificiality, potentially detrimental to their surgical performance. As a result, participants were allowed to use these products and any other prescribed or over-the-counter medications as they normally would and report usage to the test team.

Two participants reported having used a sea-sickness patch in the past month, while one participant reported using a Scopolamine patch the day he/she completed the questionnaire. Four participants also reported using sea-sickness pills. Four participants reported having used pain medication in the past month, and three reported using sleep aids. One participant reported smoking cigarettes (1 pack per week). Most participants reported drinking coffee ($n = 14$), (on average 1–3 cups per day). Caffeinated soft drinks were used by four participants, while five participants reported drinking tea (on average 1–3 cups per day).

The authors have included the OR procedures and steps required for procedure completion below in Table II. In addition to the surgical procedures, the following resuscitation procedures were performed: tourniquet placement to halt femoral artery bleed, needle decompression, tube thoracostomy, intubation, surgical cricothyroidotomy, intravenous (IV) catheter insertion, and splint placement to stabilize fractured femur.

The procedures were performed on hyper-realistic surgical mannequins called Cut Suits, manufactured by Strategic Operations,[6] in San Diego, California. Strategic Operations also creates hyper-realistic training scenarios for police, fire departments, paramedics, and military personnel. The Cut Suit includes simulated bones, visceral organs, muscle, connective tissue, and skin designed to mimic human anatomy. The Cut Suits can be set to simulate a wide variety of pathology including common improvised explosive device blast injuries. The suits are typically worn by actors during training events, but for this study, the Cut Suits were worn by manikins.

As a metric of the functionality of the CB MTF in medical operations, the movement of the surgical teams within the module was tracked using link motion analysis. This analysis was done using Xbox Kinect motion sensors, which collected data using time of flight techniques.[7,8] Xbox Kinect software and hardware has been used previously to track human motion in the setting of physical therapy and rehabilitation, as well as for patient body positioning for medical imaging studies.[9]

The Xbox Kinect allowed investigators to track six complete skeletons at one time with up to 25 joints per body. The range of tracking for each sensor was 0.5 to 5.0 M. Movements of each individual were then plotted in a schematic diagram of the OR and ER in order to quantify the movement of the medical personnel within the CB MTF. This enabled tracking of the number of movements from any point A to another point B throughout each procedure. For example, the total number of times that the CRNA moved from the head of the operating table to the anesthesia cart was counted by the system, giving a total number of movements for that participant and that procedure. Similar data were collected for each member of the

**TABLE II.** Procedures Performed During the Voyage of the Brunswick

| Procedure | Steps Involved |
|---|---|
| Injuries of the abdomen | Standard full length abdominal laparotomy incision |
| | Four quadrant trauma abdominal packing |
| | Explore abdomen (liver injury as source of bleeding, 2-cm laceration of small bowel) |
| | Specific hepatic damage control packing |
| | Repair small bowel with at least four sutures using 3–0 silk |
| | Damage control temporary abdominal closure with Ioban and drains |
| Multiple fractures of pelvis with unstable disruption of pelvic ring | Use X-ray image to locate fracture |
| | Create appropriately placed incisions over iliac crests |
| | Place two fixator pins in each iliac crest |
| | Place stabilizer bars inferior to allow access to the abdomen |
| | Dress |
| Displaced transverse fracture of shaft of left femur | Loosen splint but maintain traction |
| | Use X-ray image to locate fracture |
| | Palpate thigh to identify fracture location |
| | Make appropriate incisions proximal and distal to fracture |
| | Dissect quadriceps to expose femur |
| | Release traction |
| | Check pulse |
| | Dress and prep for transport |
| Partial traumatic amputation of left lower leg | Inspect wound, determine need for amputation |
| | Make circumferential skin incision |
| | Identify and ligate artery |
| | Amputate using giggly saw |
| | Bandage stump and prepare patient for evacuation |

surgical team in each procedure. Statisticians then averaged the number of movements of one team with the movements from the other team to obtain one baseline average number of movements from each position filled in the OR and ER. Averages of the movements were collected at the beginning and end of the study to allow comparison of the movements of participants longitudinally.

Additionally, researchers timed each procedure from start to finish as a metric of the team's ability to learn how to work more effectively onboard the ship. Time to complete procedures was stratified against sea state to determine if sea state had an impact on procedure length. For tasks completed in the OR, time to complete a procedure was included with metrics of surgical skill and performance such as suture placement, theoretical anastomotic success in the small bowel procedures, and proper pin placement in pelvic fracture reduction procedures. SME assigned grades to each procedure on a scale of one to five based on surgical performance and time to complete the task. These scores were then stratified against sea state to determine its effect on surgical performance.

## RESULTS

From the data gathered, there was a clear learning effect within the teams, both in the OR and ER. The ER procedures were generally completed more rapidly, with average time to complete tasks dropping from 7.5 minutes to <3 minutes over the course of 112 trials (Figs. 3 and 4). Time to complete

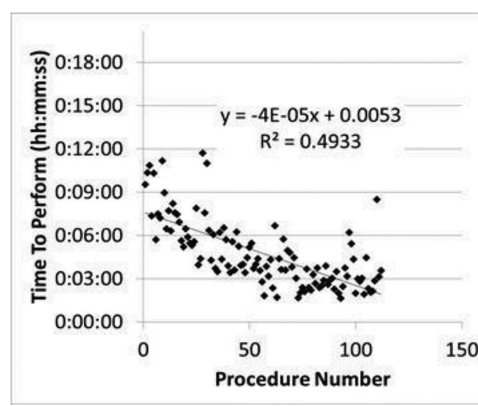


**FIGURE 3.** Time to perform task shows improvement of ER teams with experience.

tasks was stratified against sea state and showed no correlation between time to complete ER tasks and sea state with the exception of starting an IV in the left arm. Time to perform this task was significantly increased at sea state 4, but not at sea state 3 (Fig. 5). In the OR, average procedure times dropped from 13 to 9 minutes by the end of the experiment. Scores assigned by SME showed no correlation with sea state.

### *ER Link Analysis Results*

Participants mounted handholds on the ceiling of the ER early in the course of the study to provide additional support

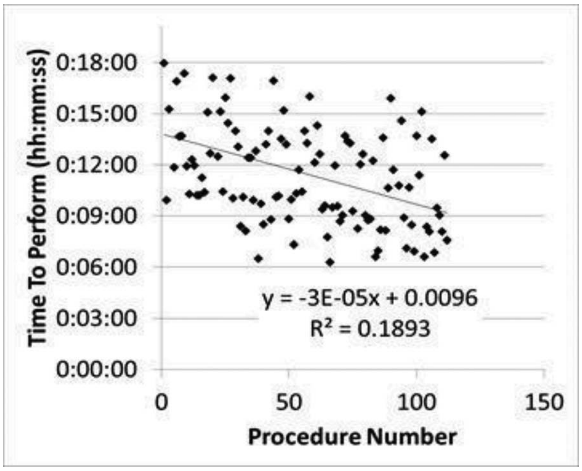


**FIGURE 4.** Time to perform task shows improvement of OR teams with experience.

for the ER personnel waiting for the next patient or next task. During procedures, the CRNA remained in a relatively constrained location, generally remaining at the head of the patient while traveling back and forth from the anesthesia cart. Occasionally, personnel other than the CRNA crossed the head of the patient in order to stabilize the upper torso or head. The Surgeon and Nurse occasionally moved from one side of the gurney to the other, depending on the patient requirements. Tech 1 and 2 generally remained on the X-ray side of the table to stabilize the large device. The Corpsman was available for tasks as needed in the patient scenario meaning that he/she moved somewhat randomly throughout the room. The X-ray setup in the ER was a consistent challenge for personnel during large deck accelerations since the device was mounted on wheels and had substantial mass. Early in the test series used two team members for stabilization of the X-ray device. Nursing personnel in the ER reported repeatedly shielding the gurney to protect the patient from potential roll. The gurney, which was also mounted on wheels, had a tendency to roll off of the marked site during large motions, the CRNA, Nurse, Surgeon, and Tech personnel from both teams periodically helped stabilize the gurney from motions. Personnel generally noted that a Corpsman was not always available in typical ER/OR scenarios, but that the availability of the additional personnel was helpful while working on the patient when using the X-ray.

### *OR Link Analysis Results*

For similar tasks at the beginning and end of the study, there is modest improvement economy of movements owing to improved team dynamics and experience. For general surgical tasks, the Surgeon, CRNA, and the Tech 2 remain relatively immobile during the operation. The Surgeon generally waited for the line to be placed by the Corpsman and then took a relatively fixed place at the side of the patient as he/she performed the surgery. The CRNA stayed in a relatively restricted area between the head of the patient, the patient monitor, and the anesthesia cart. Instruments and supplies were generally transferred by Tech 1 to the surgeon by moving to and from the work table in the OR. The Nurse facilitated the movement of supplies from the stores at the wall of the OR. During a portion of the higher sea state runs, one of the surgeons requested for the Corpsman to stabilize him during surgery (Fig. 6). This practice was not repeated by either of the other two surgeons in the study. The tasks performed by the Corpsman were generally not critical to the effective operation of the team and may possibly be omitted from the surgical team. Personnel were generally able to move around the OR without interfering with the motion of other participants. There was room on the patient left and right of the table for a second person to pass behind a person standing at the OR table, and there was enough room at the foot of the OR table to facilitate ingress and egress from the OR.

Handholds were also mounted to the ceiling of the OR early in the course of the experiment to provide rest locations for the OR personnel waiting for the next patient, or when waiting for the next task (Fig. 6). Generally, personnel sat on the floor to rest between patients. Overhead handholds were also used by personnel to stabilize themselves during high sea states.

Personnel generally noted that a Corpsman was not always available in typical ER/OR scenarios, but that the availability of the Corpsman was helpful in stabilizing the surgeon in a strategy used by the Blue team. The Red team surgeons typically self-stabilized with the table in the OR. Personnel who commented noted that the OR table was quite secure and the instrument table presented no difficulties in the motion environment. Tech1 from the Red team suggested that electrode hookups should be longer to prevent them from being pulled during movements and that the drill/bone interaction be improved for future simulations. In addition to these comments, participants noted that the ER and OR had a sufficient amount of space to work, and that it approximated the land-based facilities they typically encounter.

Despite personnel making changes to their working environment, and learning how to work in it as the study wore on, the link analysis did not show a statistically significant decrease in the number of movements of any of the personnel from the beginning to the end of the study (Figs. 7–10, Table III).

## DISCUSSION

It was hypothesized that learning and experience would have a positive effect on the ability of the subjects to perform their tasks efficiently. In many cases, this was seen. For example, the teams generally were able to perform their tasks quicker as the experiment continued, and they were able to better outline their individual roles, which enabled them to be more efficient. This observation is logical because the personnel had not worked together before the experiment, nor had they

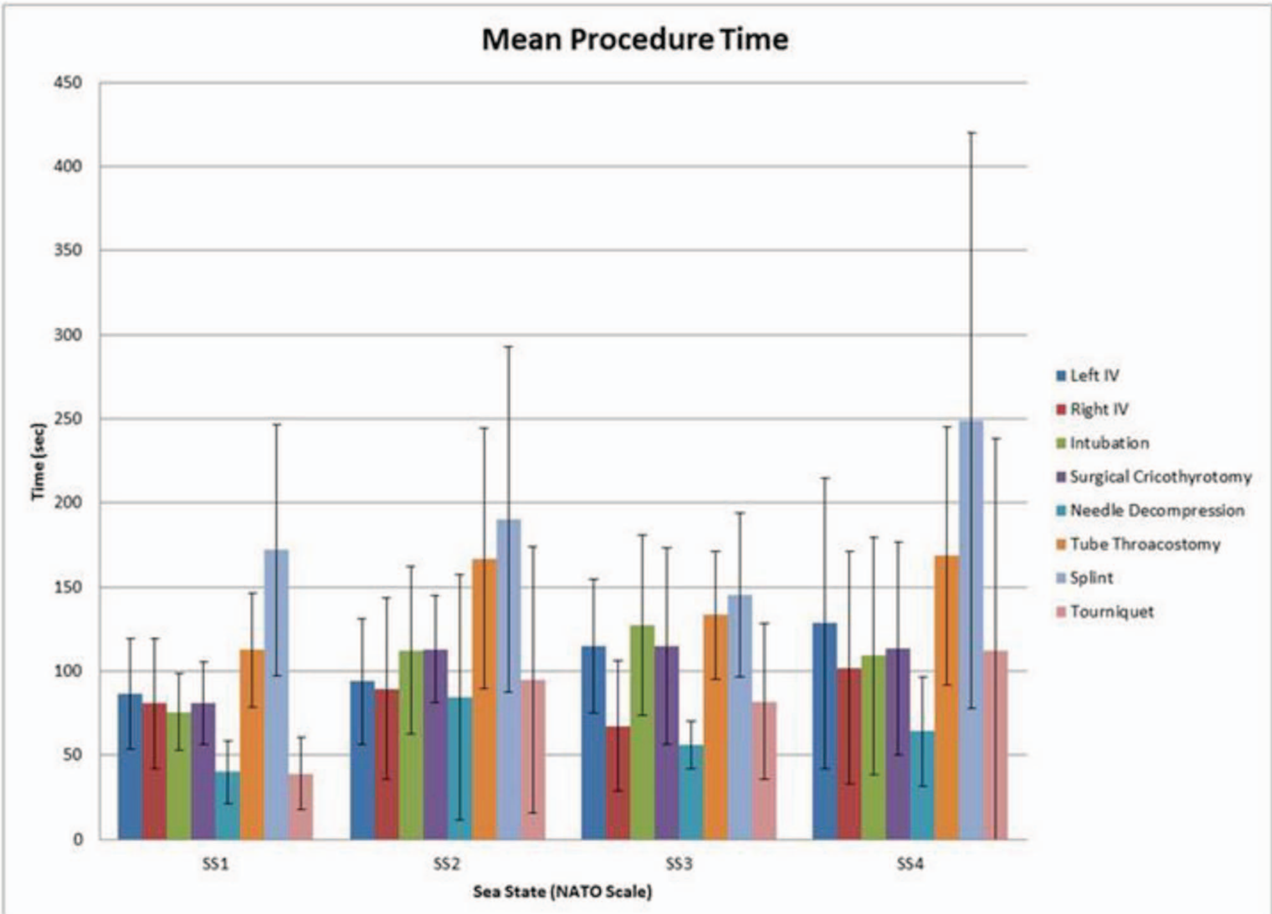


**FIGURE 5.** ER Procedure Time vs. Sea State. No correlation between sea state and ER procedure time is shown, except for a statistically significant increase in time to insert left IV line at sea state 4.

**FIGURE 6.** Nurse stabilizing doctor, use of overhead hand holds, and widening of stance for added stability.

**TABLE III.** Numerical Representation of Link Analysis

| Team Member | Surgeon | CRNA | Nurse | Corpsman | Tech 1 | Tech 2 |
|---|---|---|---|---|---|---|
| Movements at start | 3 | 9 | 11 | 7 | 9 | 2 |
| Movements at end | 3 | 7 | 7 | 5 | 9 | 2 |

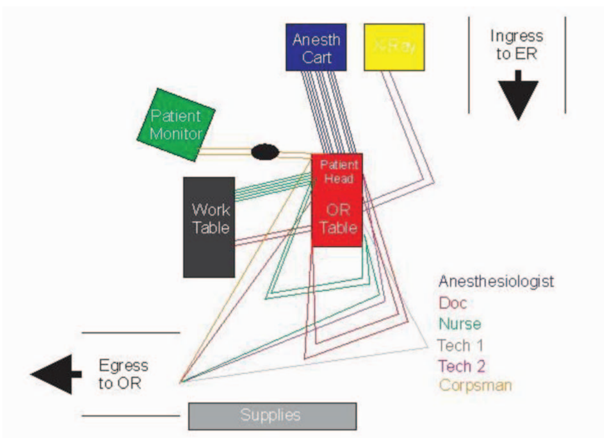


**FIGURE 7.** ER motion link diagram—beginning resuscitation task.

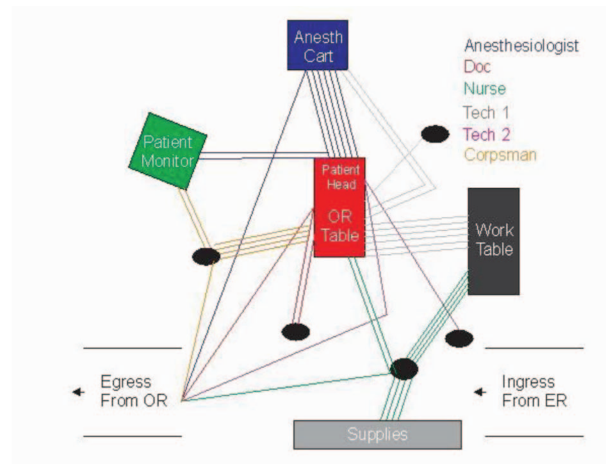


**FIGURE 9.** OR motion link diagram—beginning surgery task.

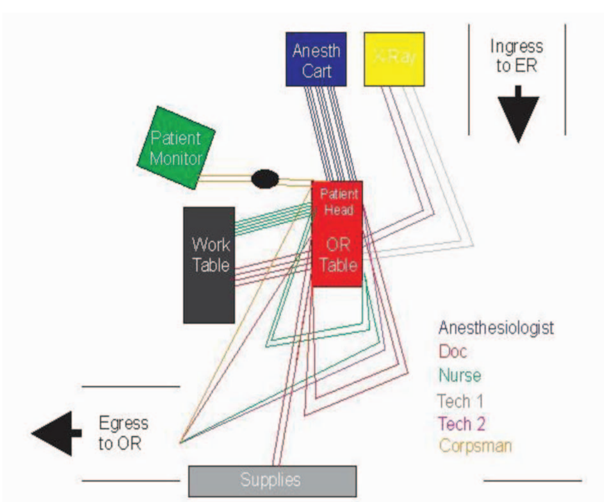


**FIGURE 8.** ER motion link diagram—end resuscitation task.

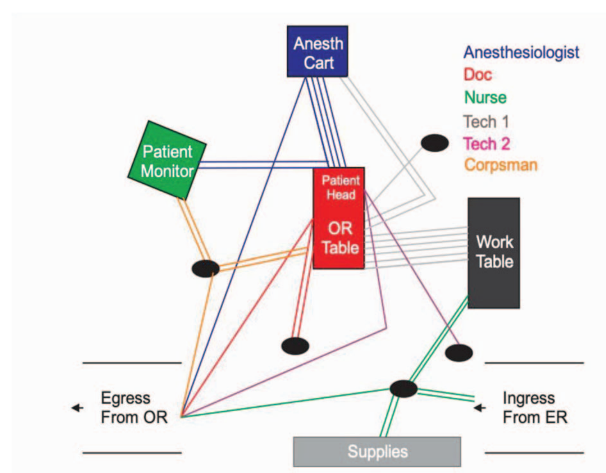


**FIGURE 10.** OR motion link diagram—end experiment surgery task.

worked in the CB MTF meaning they would had to learn how to adapt to a new environment.

However, personnel did not significantly decrease the actual number of movements made within the module during the procedures. This speaks to the functionality of the OR and ER layout and design used in the modular treatment facilities. All participants were experienced members of the medical community, highly trained, and experienced in their individual fields. These experienced medical professionals were not able to or did not need to decrease the number movements throughout the course of the study, which indicates that the layout of the MTF was a suitable enough environment from the beginning of the experiment to allow them to do their assigned duties.

It appears that the decreased time to complete tasks could be attributed to improved team dynamics, or learning how to better work together in the teams that they were assigned to for the experiment. Teams were able to learn and adapt to their new environment in many ways, but they could not or did not need to decrease the number of movements they made in the treatment facility. This likely means that the size of the work space available and the motion of the ship were not limiting factors in the ability of personnel to perform their assigned tasks.

While there is no head-to-head comparison study with land-based treatment facilities or large deck platforms, this study provides strong evidence that trauma damage control resuscitation and surgery can be performed in this CB MTF aboard ships similar in class to USNS Brunswick, in the sea states studied.

## CONCLUSIONS

Conclusions drawn from data collected in this study need be seen through the lens of limitations, which still exist on this platform. One limitation that needs to be considered is that of patient transport. Helicopters cannot land on a ship such as the Brunswick in sea states, which exceed NATO sea state 4. If a ship outfitted with the CB MTF was caught in these conditions, it would be unable to accept any patients, it would also be unable to transport patients on to a role three facility. Another limitation is patient transport on the ship itself. Ships like the Brunswick are not designed with large elevators capable of carrying a gurney with a patient between decks of the ship. This means that the CB MTF needs to be located on the same deck as the flight deck, or some method of transporting a patient between decks of the ship would need to be devised. The fact that there was no statistically significant decrease in the number of movements, according to the link analysis, indicates that the initial setup of the modular type OR and ER layouts used in this study are adequate for performing lifesaving damage control procedures on the high seas. Participants either could not or did not improve on the number of movements because they did not need to in order to complete their tasks. The data collected along with comments from participants in the study support that the facility itself is sufficient to perform damage control and resuscitation procedures on an LCS-type ship. The absence of significant change in the link analysis data may suggest that the evolving team dynamic itself along with experience were the keys to the decrease in procedure time. Medical personnel who did show improvement in their link analysis motion were participants whose roles were further defined as the experiment went on, which potentially could have accounted for the improvement. Those who did not improve were personnel whose roles in the procedure were well defined before the experiment began. The fact that the motion of participants within the facility did not change may mean that the procedures did not have to be radically modified in order to successfully perform these procedures on the high seas. It may also indicate that the Modular Treatment Facility is a reasonable asset able to fill the needs of a role 2 facility under the proper sea state conditions as mentioned above.

The results show that many of the initial challenges of conducting medical operations in high seas conditions can be overcome on smaller ships not originally outfitted for such purposes, though some still remain. This supports the idea that nontraditional US Navy ships can be outfitted with modular ORs and ERs and may allow another avenue to bring care closer to our wounded warfighters, giving them quicker resuscitation and stabilization times, and potentially, better outcomes for the soldiers, sailors, airmen, and marines, which serve our country.

Future studies may be aimed at engineering better ways to move patients while aboard ships like the Brunswick.

## SUPPLEMENTARY MATERIAL

Supplementary material is available at *MILMED* online.

## FUNDING

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