



## Managing critical care casualties on the Navy's hospital ships

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The hospital ships *USNS Mercy* (T-AH 19) and *USNS Comfort* (T-AH 20) are moored at an assigned pier and standing by for their next mission. These ships may be called upon to deploy overseas to an area in conflict to receive casualties wounded during enemy fire or they may serve as large medical centers for mass casualties injured from acts of war or natural disasters in the United States. Regardless of the mission, the hospital ships have the means and a “can do spirit” that allow them to be ready for movement within 24 hours. At any given time, resources and equipment are available to handle the large volume of critically ill patients anticipated in a war or disaster scenario. This article describes the training of the ship's medical and nursing staff and the facilities and resources for managing critical care casualties onboard these large afloat hospitals. A case scenario allows the reader to flow through the hospital ship with the patient. A historical review and the future directions for T-AH Mercy class hospital ships are presented.

### Historical review

Ships have been used as mobile hospitals and deployed with battle groups since antiquity. The ancient Greeks included the hospital ship *Therapeia* in the Athenian fleet as early as 400 BC [1]. During the Roman Empire, ships called immunes were kept free of combat duty and used for casualties of war. The *USS Intrepid* (1804) was the first American naval vessel to be converted to a hospital. This hospital ship was used to support the fleet while fighting pirates in the Florida Keys and West Indies. In the mid-1980s, the *USNS Mercy* (T-AH 19) and *USNS Comfort* (T-AH 20) were each transformed from a San Clemente class, 90,000 ton crude oil tanker to a 1000-bed hospital ship [2,3]. Today, *USNS Comfort* and *USNS Mercy* are the two largest hospitals in the world.

The *Mercy* is home-ported in San Diego, California (Fig. 1) and the *Comfort* resides in Baltimore, Maryland [2–4]. When the ships are deployed, more than 1200 US Navy Medical Department personnel, support staff, and civilian mariner crew report for duty and live and work onboard for as long as the ship is out to sea.

The hospital ships are state-of-the-art medical communities. The *Mercy* and *Comfort*'s mission is twofold [2–5]. Their primary mission is to provide acute medical and surgical treatment to Navy, Marine, Air Force, and Army personnel who are involved in combat. The secondary mission is to provide humanitarian aid globally as deemed necessary by the

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Fig. 1. USNS *Mercy* (T-AH 19) homeported in San Diego, California.

government of the United States. Shortly after her commissioning, *Mercy* sailed for a humanitarian mission in the Philippines where 63,000 patients were treated for medical conditions and 850 surgeries were performed in just over four months [3,5–7].

In 1990, *Mercy* and *Comfort* were activated to provide medical and surgical support to deployed US and coalition forces involved in Operation Desert Shield [2,3,7,8]. In 1991, Operation Desert Storm emerged and the mission for *Mercy* and *Comfort* shifted to combat medical and surgical support for Americans and their allies who were involved in the conflict. The hospital ships floated within the Persian Gulf and Gulf of Oman and the staff collectively treated more than 1400 inpatients and performed nearly 700 surgeries. Twenty-one American and two Italian prisoners of war that were released from Baghdad were also treated.

In 1994, the *Comfort* was activated for Operation Sea Signal to serve as a migrant processing and medical center for Haitian immigrants [2]. After completing the mission, the ship was assigned to Operation Uphold Democracy and served as a 250 bed hospital

whereby staff provided treatment and care to the 35,000 Cuban and Haitian refugees at Guantanamo Bay, Cuba. In 1998, the *Comfort* left Baltimore Harbor to participate in an international military exercise, the Baltic Challenge [9]. While off the coast of Lithuania, a mother from this country requested surgical care for her 13-year old son with a lipomycolminingocele (osseous horn) on the back of his head [10]. The *Comfort's* neurosurgeon and an American-trained Lithuanian neurosurgeon removed the growth and postoperative care was provided for several days before the mother and son returned to Lithuania.

Following the terrorist attacks of September 11, 2001, the *Comfort* was activated for Operation Noble Eagle and was scheduled to deploy to New York Harbor within 24 hours to receive mass casualties from the rubble of the World Trade Center's twin towers [11]. Because few persons survived the devastation of this horrific event, the mission was changed to provide logistics support and services to emergency relief personnel employed in Operation Noble Eagle. Although the *Comfort* received no casualties, the hospital ship opened its doors to

provide “comfort”, in the form of lodging, hot showers, and meals to many rescue workers from “Ground Zero” [8,11–14].

### **Staff assignment, education, training, and orientation**

During a nondeployed status, the hospital ships have a small number of full-time civilian and military staff that are assigned to maintain the ships’ operational status [2,3,15]. During full operating status, the civilian mariner crew and Navy military personnel are augmented to levels directed by higher authority. The number of medical and nursing staff who are deployed depends on the number of patient beds that are activated for the designated mission. The hospital ships may be activated to 250-, 500-, or 1000-bed medical treatment facilities.

The Bureau of Naval Personnel assigns military members to specific operational platforms (ie, hospital ship, fleet hospital), and then they work at military treatment facilities that are responsible for manning that specific operational platform. For the hospital ships, Navy military personnel are mobilized from the Naval Medical Center, San Diego, California (*Mercy*) or the National Naval Medical Center, Bethesda, Maryland (*Comfort*). Medical and nursing staff occasionally comes from Naval Reserve units, depending on the assigned training exercise or military mission.

The Bureau of Navy Medicine and the local supporting military treatment facility’s Commanding Officer continually assess readiness needs and train medical personnel for their assignment to the hospital ships. Each medical and nonmedical position requires specific shipboard knowledge and clinical competencies. Operational training requirements range from administering basic first aid to Level I advanced trauma care and critical care. To support Level I trauma care, physicians and nurses acquire advanced skills through contracts with local burn and trauma centers.

Mandatory training for shipboard duty and individualized instruction is accomplished during the quarterly *Mercy* (MERCX) and *Comfort* (COMFEX) training exercises. Nurses receive instruction in fighting fires, damage control for ships hit by enemy fire, and chemical, biological, and radiological (CBR) warfare defense. During MERCX and COMFEX exercises, staff receive hospital orientation, and unit-specific orientation including competency assessment of the ability to use equipment and perform specific skills. In addition, concepts on management of casualties are presented and skills are practiced during mass

casualty drills. Some nurses are assigned to emergency and critical care areas on the hospital ships, but work in other areas within the Naval Medical Center to which they are assigned. To gain emergency or critical care experience, these nurses are given the opportunity to cross-train in the Emergency Department or Intensive Care Unit at the Naval Medical Centers.

A number of formal trauma and critical care courses are available for nurses who are assigned to emergency and critical care areas of the hospital ships. The Trauma Nursing Core Course is offered at the Naval Medical Centers and is required for all nurses. The Society of Critical Care Medicine developed the Fundamentals of Critical Care Course that is available to medical and nursing staff who are assigned to the hospital ships. This 2-day course offers skill stations, lectures, and guidance for decision-making in the care of critically ill patients during the initial hours of management when consultative critical care expertise may not be available. Finally, a CD-ROM library of trauma training is available onboard the hospital ships and can be accessed from computers in each area of the ship.

The integration of all training is tested routinely when the hospital ships participate with the fleet and Marines in exercises Baltic Challenge (*Comfort*) and Kernal Blitz (*Mercy*). During these exercises, an operational scenario is played out that includes receipt of mass casualties by helicopter while the hospital ships are at sea.

### **Management of casualties**

#### *The contaminated casualty*

The hospital ship is operationally vulnerable when weapons of mass destruction, such as CBR warfare, are used. Risk of exposure to chemical and biological agents occurred during the Desert Shield/Desert Storm (DS/DS) conflict. The civilian mariner crew and medical, nursing, and support staff onboard ship were drilled extensively in the policies and procedures that are associated with chemical/biological warfare, including confirmation of agent exposure, counter defensive measures, and protective actions for patients and crew members. Following DS/DS, the Navy Medical Department and the Military Sealift Command conducted extensive ventilation flow studies to determine safe and effective procedures for Chemical Patient Decontamination before admission to the ship’s interior clinical areas.

The ship design of the late 1980s imposes restrictive limitations on the volume and type of patients

who can be accepted for decontamination. Operational policies and procedures dictate that contaminated patients undergo primary decontamination in the field before casualty distribution and embarkation onto the hospital ship. Because of the excitement, stress, and confusion during war, contaminated patients may be among the mass casualties that are received by the hospital ships. Selected members of the ship's medical and nursing staff are assigned to a patient decontamination team and are extensively trained for this role [16,17]. The Navy Medical Department developed a comprehensive training video that outlined specific guidelines for using detection equipment, performing patient decontamination, and patient monitoring after chemical exposure.

During didactic training, patient decontamination team members are taught to recognize signs and symptoms of chemical, biological, and radiological contamination and mechanics of decontamination. The team's knowledge and skills are tested when they participate in mass casualty drills during quarterly MERCEX/COMFEX training exercises. Several mass casualty scenarios that are played out during these exercises include receipt of contaminated patients. The patient decontamination team must respond to the situation; their performance is evaluated in accordance to the guidelines for decontamination.

Medical monitoring of the patient decontamination team is paramount to avoid heat exhaustion from wearing Mission Oriented Protective Posture (MOPP) gear for an extended period of time. Methods to prevent heat exhaustion include education and use of supplemental teams for scheduled rotations with the primary team.

The optimal management of patients who had been exposed to airborne infectious disease on the hospital ship was a challenge that was tested during Operation Sea Signal, where the *Comfort's* mission was to provide medical treatment to Haitian immigrants. The ship was activated and outfitted with a specially designed medical contingent to support this operation. On arrival at the mission location, medical intelligence confirmed the presence of active communicable diseases associated with the Caribbean geographical region. Tuberculosis was a disease management priority for the Haitian refugees. Because of ventilation design limitations on the hospital ships, the patients with active TB were housed in general purpose tents on *Comfort's* "steel beach", a large exterior surface on the topside of the ship (Fig. 2). Portable diagnostic (laboratory and radiology), dietary, and sanitation services were set up nearby and prevented unnecessary movement of patients and spread of disease during this operational mission.

Since completion of Operation Sea Signal, numerous studies were conducted to determine the optimal ventilation and physical designs for a negative flow isolation unit on the hospital ships. During the spring of 2000, an 11-bed space in the aft (rear) ICU was converted into a negative flow isolation unit. The 11 beds fit into four, specifically-designed, plastic-draped pods, each capable of housing different types of infectious disease patients.

#### *Patient arrival and flow*

##### *Transport to hospital ship*

Although wounded military personnel can be delivered to the hospital ship by way of another ship, small boats, or directly from a pier, most arrive by helicopter. There is one landing pad on each ship near the decontamination station, elevators, and ramp for transfer to the ship's casualty receiving trauma center. The wounded who are triaged based on the degree of injury and best chance of survival, are transported to casualty receiving by way of three elevators, each with a six-litter capability.

All wounded are triaged on the flight deck of the ship. The triage team consists of a medical officer, generally an emergency medicine physician, and ancillary staff that consist of independent duty corpsmen and general duty hospital corpsmen. Hospital corpsmen are highly trained medical technicians with a scope of practice similar to that of a licensed practical nurse. A crew of "able-bodies" is also available to aid in litter transport. No surgical or medical resuscitative interventions are conducted during initial triage on the flight deck. The hospital ship is an Echelon III level of care; initial treatment from the field is noted on the patient's casualty tag, which is generally attached to their dog tags.

One category of triage is "minimal" or "non-acute". Patients in this category are often referred to as the walking wounded as they may have minor abrasions, lacerations, and broken bones, yet are able to walk. A wide passageway, or ramp, runs from the deck of the ship to the seven decks below. Just two decks below, the ramp opens to the predesignated nonacute area of casualty receiving. The walking wounded are treated and determined ready for redeployment to their battalion or unit, whereas others are moved to wards for further evaluation or convalescence.

A second category of triage is "delayed" or "urgent". In this category, patient injuries are significant and they require surgical intervention, but their hemodynamic status can be controlled with



Fig. 2. Care for Haitian immigrants on “Steel Beach”.

fluids, blood products, oxygen, pressure dressings, and watchful monitoring by the nurses and corpsmen.

“Immediate” or “emergent” is the third triage category. These patients have life-threatening injuries or illnesses that require immediate surgical and medical intervention to avoid loss of limb or death. If multiple casualties are received onboard, the immediate patients are further triaged to available operating rooms or the operating room “prep and hold” area for invasive monitoring, oxygen and possibly, ventilatory support, and fluid resuscitation.

A fourth triage category is “expectant”. This term is used to designate those soldiers or sailors whose chance of survival is very low and whose wounds require extensive resuscitative resources such as surgeons, nurses, corpsmen, blood, IV fluid, operating room time, and so forth, that might otherwise be used to save many. The wounded in this category are transferred to a designated area in casualty receiving where they are treated for pain and provided spiritual support by the ship’s chaplains. If the opportunity exists to surgically intervene, then patients in the expectant category will be re-evaluated and retriaged to a higher priority of care.

#### *Equipment and clinical support services*

The patient flow onboard ship is uniquely designed. On the main deck of the ship, the most forward compartment is casualty receiving. Throughout the ship, all monitoring equipment is portable and interchangeable with the operating room (OR), post-anesthesia care unit (PACU), and intensive care unit. Laboratory tests, portable-digital-radiologic examinations and ultrasound examinations can be conducted in casualty receiving or en route to their next destination. Once completed, the patient is transported aft (rear) to the OR holding area, then the PACU, and finally the ICU or ward. The flow is designed so that patients are always moving aft, barring any unforeseen complications. This method of patient flow provides an incredibly efficient means of managing care and tracking patients.

#### *Casualty receiving*

Casualty Receiving (CASREC) is a 50-bed area that is divided into several pods or bays that hold four to six gurneys. Each bed space has state-of-the-art monitoring equipment, an oxygen delivery system, and a well-stocked supply cart. Designated nurses,

corpsmen, and surgeons are prestaged in each bay (Fig. 3). All emergent care is delivered here.

On the patient's arrival and using the "ABCs" of trauma management, the nurse-physician-corpsman team complete a thorough assessment, provide resuscitative treatment, and determine the disposition of the patient. This is done for all patients who arrive by way of elevator. The patient is assigned a registration number and tag that will be used to track the patient's stay onboard ship and is prepared for transport to the next echelon of care or the return to the battlefield.

#### *Operating room and OR holding*

There are 12 operating rooms and a six-bed holding area. Once again, each OR space has state-of-the-art equipment. In addition, there are two dental operative suites. The OR is strategically placed in the exact center, or core, of the ship to minimize motion and vibration. With the exceptions of cardiac surgery, transplantation, and total joint repair, all other major and minor surgical procedures can be performed.

#### *Postanesthesia care unit and intensive care units*

The combined bed space in PACU and the four ICUs is 100 beds. Each unit has a 20-bed capacity. Similar to CASREC, each ICU is divided into five bays that hold four gurneys each. Columns near bed spaces hold the monitoring equipment and an oxygen delivery system (Fig. 4). A central monitoring system allows for the simultaneous monitoring of all 80 ICU beds. The latest model ventilators, intracranial pressure monitors, and patient transport monitors are available. In an area adjacent to the ICUs, hemodialysis can be performed with the ship's new hemodialysis units. Respiratory therapists and dialysis technicians are assigned to the Critical Care areas and are readily available to care for patients who require their services. Nurses and corpsmen are assigned patients based on acuity.

Patients may require admission to the ICU for a wide range of reasons including airway observation postthoracic surgery, telemetry monitoring postmyocardial contusion, or acute lung injury posttraumatic insult to the chest. Postoperative patients may be



Fig. 3. Casualty Receiving on *USNS Mercy*.



Fig. 4. Intensive Care Unit on *USNS Mercy*.

recovered in the PACU or the ICU. One nurse and one hospital corpsmen are assigned to each four-bed bay.

#### *The wards*

There are 900 additional beds that are divided into several wards based on three levels of progressive care: immediate care, light care or limited care. One 80-bed ward is designated as a medical ward as it is the only ward with two heads (bathrooms), which are needed when isolating patients during outbreaks of diarrheal disease. One unit is designated for psychiatric patients. Patients in limited care are ambulatory, ready for evacuation, and eat their meals in the ship's galley. The wards can be designated further for men and women. In a humanitarian aid situation, families would be housed together to promote cohesion and eliminate or minimize language barriers.

Each ward has full galley (kitchen) capability where prepared food is served and dishes are washed and stored. Juices and snacks are also stored in refrigerated units. The bathroom (head) on each ward is limited such that there is only one per ward (except

the medical ward), thus the additional need to separate men and women. Warm showers and flushing toilets are standard shipboard capability.

The "nursing station" is anything but modern. The traditional design includes metal chart racks and charts, locked cabinets for medication administration, and a single desk and chair. The nurse's stations are centrally located to maximize visibility of patients throughout the wards. Portable furniture and equipment, including all gurneys and ventilators in CAS-REC, the ICUs, and ORs, are literally "tied down" to the deck to metal D-rings with metal and plastic fasteners for stability.

#### *Case scenario*

JB, a 21-year-old Navy Petty Officer, sustained a gunshot wound to the left upper abdomen during an encounter with hostile forces. Hospital corpsmen in the field applied a pressure dressing to control bleeding and quickly transported him to the Battalion Aid Station (BAS). At the BAS, bleeding was stabilized, intravenous access was established, and his pain was treated. He was placed on a spine board for a

potential spinal cord injury. Within 30 minutes of arrival to the BAS, he was evacuated by helicopter to the *USNS Comfort*.

The Blackhawk helicopter landed on the ship's helo-pad and patients were unloaded onto the flight deck for triage. JB's initial triage category on the flight deck was "immediate" and he was transferred to CASREC on a litter by way of elevators. He was met by the triage officers and assigned to Bay 5 for continued evaluation and treatment.

JB was alert and oriented with no focal neurological deficits. His vital signs were: BP 100/70, heart rate of 100, and respiratory rate of 20. He described a pain score of 6 on a 0 to 10 Numerical Rating Scale and was given 4 mg of IV morphine. The two 18 gauge peripheral intravenous lines inserted in the field were patent, and maintenance fluid of NS at 125 mL/h was started. Stat laboratory tests were ordered (CBC, SMA-7, and type and cross for two units of packed red blood cells). Results showed a hgb/hct of 10/29, potassium of 3.5 meq/L, and glucose of 80 mg/dL. A portable chest radiograph and C-spine series were normal. The spine board remained in place until more definitive radiographic views were available and surgeons were ready to operate. His abdomen was tender to the touch and firm. During secondary assessment, an entrance wound was found in the upper left quadrant and an exit wound was found on the left flank. Pressure dressings were secured and JB received an initial dose of antibiotic therapy. He was triaged as "delayed" and transferred to the ICU for continued monitoring and treatment. His triage status was based on his stable hemodynamic status in light of a gunshot wound and nonavailability of an OR.

JB was transported for a CT scan enroute to the ICU to evaluate the extent of injury. Once in the ICU, he was placed on a monitor that revealed sinus tachycardia at a rate of 110 and a SpO<sub>2</sub> of 98%. Remaining vitals included blood pressure of 88/40, respiratory rate of 26 breaths per minute, temperature of 99.2°F. A bolus of 500 cc NS was initiated and a Foley catheter was inserted, which produced a small amount of rose-colored urine. His abdomen became firm, distended, and without audible bowel sounds. His pain increased from 3 to 6 over 10. The abdominal dressing was dry and intact. There was no improvement of his vital signs following the bolus, so two units of packed RBCs was given. A nasogastric tube was inserted and placed at low continuous suction; a scant amount of hemocult-negative clear fluid emerged. The physician and nurses assessed JB for active bleeding by logrolling him onto his side and found that blood had pooled on the spine board soaking into his clothing. His exit wound was bleeding. Pressure dressings were applied to the

wound and he was quickly transported to the OR. Following surgery, JB returned to the ICU in stable condition after having his spleen removed because of the initial gunshot injury. His left kidney sustained slight injury that did not require surgical intervention. He was extubated shortly after arriving in the ICU. His plan of care included pain control, pulmonary toilet, Foley catheter to gravity drainage, nasogastric tube to low constant suction, hemodynamic monitoring by way of arterial line, and central venous pressure monitoring. He was stable for transport on his third postoperative day and was transferred to a military hospital in Germany.

### **Future direction for T-AH Mercy class hospital ships**

Following the attacks on September 11, 2001, plans for the hospital ships have included a humanitarian role as part of the Homeland Defense Program (T. Stewart, personal communication, 2002). The Navy will work with local disaster organizations to identify the role of the hospital ships in responding to disaster or humanitarian needs. This includes evaluating the hospital ship's capability to care for critically ill patients of all ages, including infants and children.

A number of military and civilian personnel have offered an opinion on the viability of maintaining the "Great White Elephants" [5,12,18–20]. Valid concerns were voiced about their massive size and subsequent extraordinary maintenance costs in a time when military conflicts seem to be generating significantly fewer casualties. Suggestions to use smaller decommissioned amphibious military ships or smaller commercial vessels may be viable options.

Key points in the conversion of any ship to hospital capability include stability to perform surgery in rough seas, large enough in size to support operating rooms, intensive care beds and convalescent beds, small transport helicopter landing platforms, medical control and transport for patient movement to other echelons of care, and appropriate power conversion to support making potable water and cleaning surgical instruments and patient care items. Today, one must also consider the serious threat of biological and chemical weapons of mass destruction and how and where exposed soldiers and sailors will be managed while not putting other patients and a ship's crew at risk.

Although the authors of this paper do not have the answer to this issue, we do have an opinion on the future of the hospital ships. Recent news reports include the possibility of using a quarter of a million

ground troops in future military actions. That translates into a high probability of casualties throughout the duration of the conflict. The cost of maintaining two 1000-bed hospital ships and the cost of training personnel to care for the casualties of war is inherent in the commitment to the price of peace and freedom.

## Summary

In this article, a history of the hospital ships was recounted. Recent missions were described in terms of the ship and crew's capability based on education and mock training exercises. Patient flow was described and a case scenario was presented to illustrate surgically intensive management of critical care casualties. Finally, thoughts on the future of hospital ships were discussed.

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