Chapter 26

SHIPBOARD MEDICINE

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INTRODUCTION

This chapter is being published as an update to Chapter 29, Shipboard Medicine, in *Medical Aspects of Harsh Environments, Volume* 2.[1] Many of the operational environments described in this chapter have been updated to reflect new and emerging technology and medical equipment. The references and figures have been updated as well.

The shipboard environment influences how medicine is practiced at sea. Even at sea, medicine is still medicine: diagnosis still requires a medical history and examination, diagnostic adjuncts are weighed against resources, and treatment is based on the universal principles of surgery and medication. And yet, being at sea is different. Short of space travel, the stress of close living quarters, isolation, and a hazardous environment is unequaled. The prolonged absence from home, community, and normal environment creates profound emotional stress. Shipboard isolation also precludes normal exposure to minor infections, rendering an entire crew not only immunologically isolated but also immunologically naïve, compared with shore populations. The cramped living and working spaces create complicated and unnatural challenges for hygiene, nutrition, and infection control. The ship is also a unique industrial environment, which carries additional occupational medicine concerns.

Although there are no diseases unique to ships, several factors make shipboard medicine unique.

- Medical personnel are fully integrated with their patients (ie, the crew) and the life of the ship.
- The medical officer (MO) must not only plan for every medical eventuality, but also fully interact with all other departments for all battle group events.
- Medical operations vary widely with the different phases of the ship's cycle.
- Roles that customarily belong to public health departments, industrial hygienists, and hospitals belong to the ship's medical department.

There are few books on shipboard medicine,[2,3] and this chapter adds to the topic area by focusing on military medicine on surface ships; medical problems aboard submarines are substantially similar[4] and will not be addressed here.

OVERVIEW OF SHIPBOARD CONDITIONS

Organization Aboard Ship

The ship as an organization has many of the same departments and key positions seen in other large military units. However, sea service traditions and unique seafaring features have evolved into special roles and titles, so that terminology sometimes differs from other services. For example, in the US Army a quartermaster is a storekeeper; on a ship, a quartermaster is a navigational expert. "First lieutenant" is not the rank but rather the title of the officer who runs the deck department, which takes care of all the lines (ropes), deck appliances, boats, and the architectural concerns of the ship. Similarly, the captain, also known as the commanding officer (CO) of a small ship, may hold a lower rank, such as commander.

The survival of a ship and its crew depends on watch stander vigilance. Watch standing is a system that divides duties and responsibilities among qualified personnel on a rotational basis in order to operate a ship continuously. The ship has a special document, the Watch Quarter and Station Bill, which assigns every crew member to watch standing rotations and specific positions and duties for military action or emergencies at sea. The bill for each department is posted where everyone can see, and crew members are expected to memorize their own assignments and those of their shipmates. Watch standers may be alone for long periods and fatigued from their ordinary work; staying awake on watch can be difficult, and staying alert may be even more so. Therefore, the watch standing culture and responsibility are immeasurably important, both for the safety and health of the crew and because medical watch standers are the first line of treatment in an emergency.

Ships and Missions

While ultimate responsibility on a ship rests with the CO, it is the MO's responsibility to thoroughly assess the medical needs of a ship's crew and keep the CO informed of the department's status. A coastal freighter with a crew of 15 has less need, fewer resources, and an entirely different class of medical threats than an aircraft carrier with 100 jet aircraft and several thousand crew members. Only through a thorough understanding of the ship, the ship's cycle, and its specific missions can the MO give the CO necessary information regarding requirements to provide optimal care for the crew.

There are many classes of US Navy ships; several of these ship classes and their medical department assets are described in Table 26-1. Warships are unique for their complex surveillance programs, training requirements, and dangerous environments. The aircraft carrier is one of the largest ships in the fleet, with a complement of 5,000 crew members and a very large medical department. The aircraft carrier operates one of the most complex and hazardous environments afloat. Figure 26-1 shows the USS *Ronald Reagan* (CVN 76), underway in the South China Sea with vessels from the Japanese Defense Force.

In many cases, the medical department's responsibility is not limited to the ship's company. An amphibious attack ship may start with a crew of 1,000, but when it embarks there are an additional 2,000 Marines aboard along with 70 helicopters and jet aircraft. A large medical department is required simply to care for all the people. Furthermore, when the ship enters amphibious operations, it becomes a hospital for ground troops, many of whom will be transported from other ships, so even more medical personnel are needed.

Life Aboard

From the time a ship is commissioned until it is decommissioned, it is never "turned off" or left unmanned. Ships at sea are large factories performing inherently dangerous operations that pose hazards for assigned crew members at all times as they work, eat, and sleep. Work hazards on the flight deck include helicopter and jet landings. During helicopter operations, personnel are exposed to noise, prop wash, flying debris, fuel, and fuel combustion products. Figure 26-2 shows an MH-60S Sea Hawk maritime helicopter during resupply operations on the deck of the guided-missile destroyer, USS *Barry* (DDG 52). Aircraft landings and takeoffs involving jets like the fighter attack F/A-18E/F Super Hornet can be particularly hazardous on the flight deck because of the catapult cable movement and danger due to snapping during landing operations with the arresting cable. Steam catapults with their rapidly shutting transoms are further injury sources. Figure 26-3 shows an F/A-18E/F Super Hornet landing on a carrier deck.

Ship personnel direct aircraft movement on the flight deck, and these operations present unique hazards. In the crowded on-deck environment, tractors that tow aircraft pose a significant collision hazard to deck personnel. Figure 26-4 shows an aviation boatswain's mate directing a C-2A Greyhound aircraft on the flight deck. Sailors who haul fueling lines on deck face wet and windy environments and slippery deck surfaces, both of which increase the risk of falling overboard. In addition, sailors are exposed to lifting hazards and skin contact when working with jet fuels. Figure 26-5 shows a sailor carrying a refueling hose on the flight deck.

The tension on the lines that hold two ships together during underway replenishment can be extremely hazardous for nearby sailors on deck, particularly if the lines break or snap back, which could cause severe injuries such as amputation or decapitation. Figure 26-6 shows underway replenishment operations between the nuclear aircraft carrier USS *Ronald Reagan* and Military Sealift Command fleet replenishment oiler USNS *Guadalupe* (T-AO 200).

Excessive heat and noise pervade the engineering spaces, boiler rooms, and machinery compartments. Steam pipe insulation poses an asbestosis threat to crew members and the steam itself is dangerous if the pipes break. All kinds of equipment constitute electrical hazards. Toxic fumes and materials from welding, paints, batteries, and the amalgams and epoxies the dental department uses for fillings are ubiquitous.

In addition to those hazards, shipboard life presents challenges simply because of confined space; even with the very largest ships, space is always critical. Although habitability on military ships has improved over the last 50 years, life aboard is still more arduous than living ashore or in barracks. Enlisted crew racks (ie, beds) typically have only 20 to 36 in. of vertical clearance between them, and usually are stacked three to five racks high. On amphibious ships, the embarked troops may have racks with even less clearance stacked up to six high.

A rack is a sailor's only private place; most ships have curtains that can close off each rack for further privacy and darkness. Racks are usually arranged in rows that form small, room-like enclaves to permit a sense of community and some privacy. Berthing assignments customarily place people with members of their own department in similar pay grades. The inclusion of women in crews requires more ingenuity to maintain departmental and rank-based berthing that separates men and women. Since the ship operates around the clock, invariably some crew member is beginning a watch or regular work duties in the middle of an adjacent sailor's sleeping period. This traffic adds to the already difficult challenge of sleep hygiene and schedule accommodation.

Ventilation is critical in the confined berthing compartments, so many vents are located in the overhead (ie, the ceiling). Many other projections dangle from the overhead and intrude into the space above the top rack. The berthing areas are crowded with racks, lockers, ship fittings, and other sailors. Simple daily

TABLE 26-1

CLASSES OF SHIPS AND THEIR MEDICAL DEPARTMENTS

Ship	Function	Total Personnel	Medical Department Personnel
Destroyers, DD class; Frigates, FF class; 4,500–8,000 tons	Surface patrol and combat, ASW	200–300	2–3 corpsmen, at least one an IDC. Small sick bay with 1 operating table and ≤3 infirmary beds. 2–3 BDSs.
Cruiser, CG class; 8,000–10,000 tons	Anti-air warfare, surface patrol and combat, missile warfare	450–600	1 IDC, 2–3 corpsmen, 4 ward beds. Sick bay slightly larger than on DD or FF. 3 BDSs. No full OR or ICU
Auxiliary (service) ships, AD, AGF, AOE, AOR, AR, AS classes; 10,000–20,000 tons	Logistics, supply: general replenishment, ordnance, fuels	300–500	1 GMO, 1 PA or nurse practitioner; often a dental officer (DO). 5–10 corpsmen. Larger sick bay with 1 operating table and 1–2 examining tables, 1 dental operatory. Usually 5–13 infirmary beds. 2–3 BDSs.
Aircraft carrier, CVN (nuclear power); 75,000–92,000 tons	Tactical aircraft, ASW helicopters, power projection and joint operations	> 5,300	6 MOs (including 1 general surgeon, 1 family physician or internal medicine physician and a senior medical officer who has completed a residency in aerospace medicine); 2 or 3 flight surgeons from embarked airwing. 1 RN, 1 CRNA or anesthesiologist, 1 PA, 4 dentists (1 an oral surgeon), 30 corpsmen, 13–14 dental technicians. 1 OR; audiology booth; endoscopy, pharmacy, and X-ray facilities; and laboratory. 4–6 BDS.
Command Control ship, LCC class; 19,000 tons	Command and Control of fleet, theater, and Amphibious Task Force Operations	720–900	1 MO and 1 dentist (plus a senior MO on the embarked flag staff for staff planning), 12 corpsmen (at least 1 IDC), and often a PA, 3 dental techs. 20 ward beds, and 4 "quiet beds" that can be more intensive.
Tank Landing ships, LST class; 8,450 tons	Transport and land amphibious vehicles, tanks, and combat vehicles and equipment	> 700	5 corpsmen, 1 IDC. Embarked Marines may bring 12–20 corpsmen. Occasionally, embarked Marines may also have 1 GMO. Med Dept has lab and X-ray capability. 9 ward beds.
Amphibious Assault ships, LHA, LHD, and LPD classes; 40,000 tons	Primary landing ships, and sea control, large troop carrying helicopters and VSTOL jets (Harriers)	> 3,000 (ship's company and troops)	Ship's company has 1 MO, 1 dentist, 15–17 corpsmen. Embarked troops have 1–2 flight surgeons, 2 GMOs, and 12–20 corpsmen. Embarked surgical team to operate the large operating and ward suites: 3 MOs, including at least 1 surgeon, 1 anesthesia provider, 2 RNs (1 a perioperative specialist), 1 medical regulator, 10–12 corpsmen. Medical suite 4–6 ORs, 17 ICU beds, 40–50 ward beds, and 300–500 overflow beds.
Hospital ships, T-AH class; 69,400 tons	Mobile, flexible, surgical and intensive full hospital for combat and other operations	≥1,300 patient census	12 ORs, 80 ICU beds, 20 recovery beds, 280 intermediate beds, 120 light care, 500 limited care. Lab, X ray, pharmacy, and blood bank facilities. 55 MOs, 6 dentists, 172 nurses, 20 MSCs, 674 corpsmen, 16 dental techs.

ASW, antisubmarine warfare; BDS, battle dressing station; CRNA, certified registered nurse anesthetist; GMO, general medical officer; ICU, intensive care unit; IDC, independent duty corpsman; MO, medical officer; MSC, Medical Service Corps; OR, operating room; PA, physician assistant; RN, registered nurse; SMO, senior medical officer. Adapted from: Riley, T. Shipboard Medicine. In: Pandolf KB, Burr RE, eds. *Medical Aspects of Harsh Environments Volume 2*. Washington, DC: Borden Institute; 2002: 882.

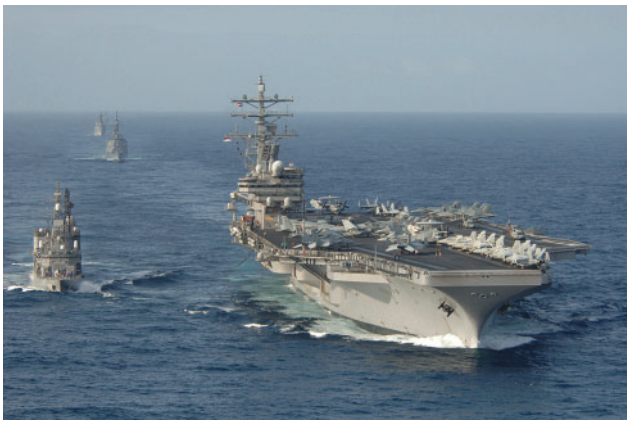

Figure 26-1. USS *Ronald Reagan* (CVN 76) steams alongside JS *Hamagiri* (DD 155), JS *Myōkō* (DDG 175), JS *Haruna* (DDH 141), and JS *Yūgiri* (DD 153) of the Japan Maritime Self Defense Force in preparation for a refueling at sea evolution March 17, 2007. The *Ronald Reagan* Carrier Strike Group is underway on a deployment in support of US military operations in the Western Pacific.
US Navy photo by Chief Mass Communication Specialist Spike Call. (Released). Reproduced from: http://www.defenseimagery.mil/imageRetrieve.action?guid=6719ec3648fa2930775e795d84832f7d81befc74&t=2.

events, such as dressing, are difficult when the six to twelve people in a cubicle try to accomplish it at the same time in a deck space that may be only 3 or 4 ft by 8 or 10 ft.

Showers, sinks, and commodes are called "heads" on a ship and are usually distributed among berthing departments. With several dozen sailors per shower and commode, heavy use can overwhelm the ventila-

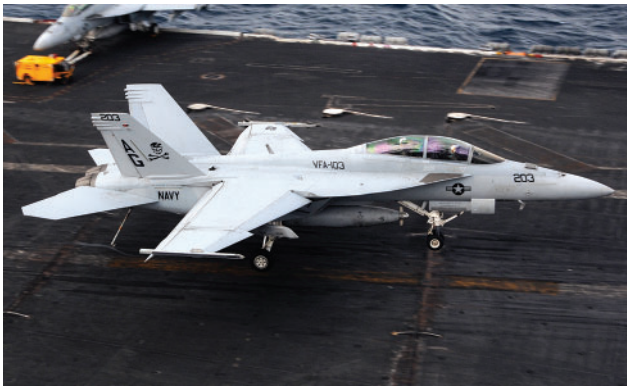

Figure 26-3. An F/A-18E/F Super Hornet prepares to catch the arresting cable on the aircraft carrier USS *Dwight D. Eisenhower* (CVN 69).
US Navy photo by Mass Communication Specialist 3rd Class Chad R. Erdmann. Reproduced from: http://www.navy.mil/view_image.asp?id=86449.

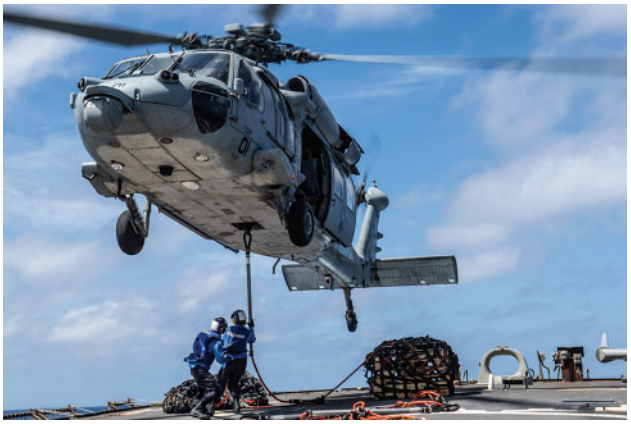

Figure 26-2. Two seaman attach cargo pendants to an MH-60S Sea Hawk helicopter, assigned to Helicopter Sea Combat Squadron 25 (HSC-25), on the flight deck of guided-missile destroyer USS *Barry* (DDG 52).
US Navy photo by Petty Officer 2nd Class Kevin V. Cunningham. Reproduced from: http://www.navy.mil/management/photodb/photos/161006-N-UF697-396.JPG.

tion in those compartments. If showers do not dry between uses, fungi, soapy residue, and bad odors accumulate. Sailors then avoid the bad shower and use one in a different area, so that it, too, is overwhelmed.

Tight living and working conditions have obvious health implications. Many jobs on ship cause crew members to sweat and expose them to petroleum prod-

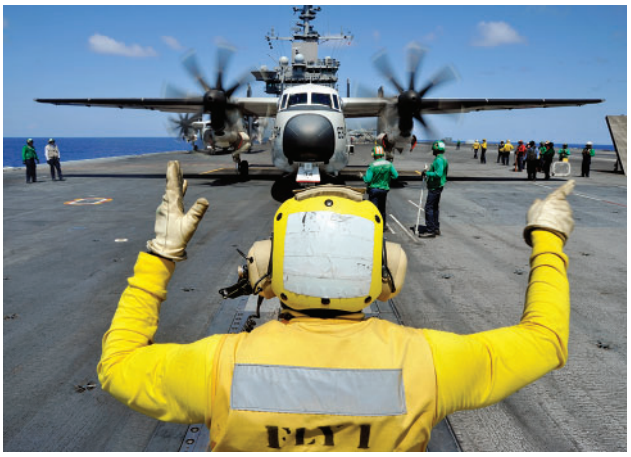

Figure 26-4. An aviation boatswain's mate directs a C-2A Greyhound high-wing cargo aircraft assigned to Carrier Airborne Early Warning Squadron 120 (VAW-120) onto a catapult as it prepares for takeoff on flight deck of the aircraft carrier USS *Harry S. Truman* (CVN 75).
US Navy photo by Mass Communication Specialist Seaman Lorenzo J. Burleson. Reproduced from: http://www.navy.mil/gallery_search_results.asp?terms=air+craft+carriers&page=9&r=4.

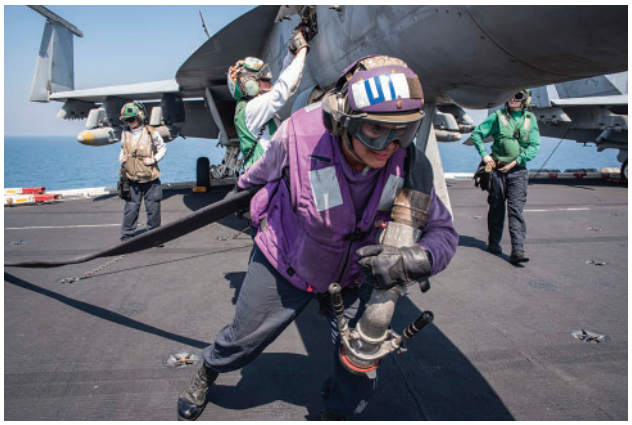

Figure 26-5. A sailor brings a refueling hose on the flight deck of aircraft carrier USS *Dwight D. Eisenhower*.
US Navy photo by Seaman Joshua Murray.
Reproduced from: http://www.navy.mil/management/photodb/photos/161006-N-WC455-093.JPG.

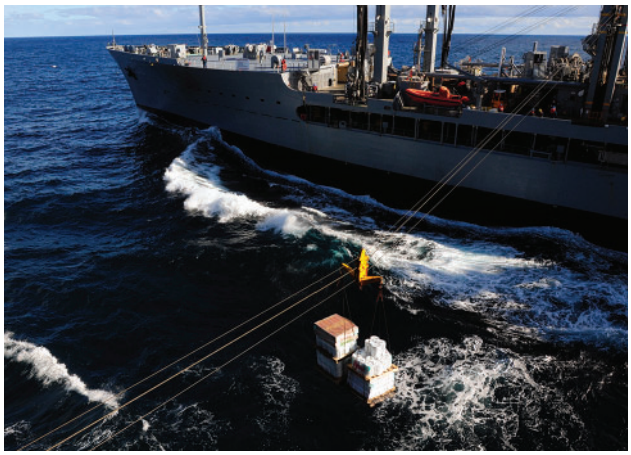

Figure 26-6. Supply pallets are sent from the Military Sealift Command fleet replenishment oiler USNS *Guadalupe* (T-AO 200) to the aircraft carrier USS *Ronald Reagan* during a replenishment at sea.
US Navy photo by Mass Communication Specialist 3rd Class Alexander Tidd.
Reproduced from: http://www.navy.mil/gallery_search_results.asp?terms=supply+underway&page=3&r=4.

ucts and dirt. Lice and other parasites are a constant threat. To prevent eczema and contact dermatitis, crew members must have clean, dry garments, yet clothing and boots do not dry well in crowded spaces, so access to clean garments and laundry service are more important at sea than under other circumstances.

Primary prevention is critical for diseases spread by respiratory routes or personal contact, which can infect dozens of sailors within a few hours. An influenza outbreak could rapidly devastate a crew, so vaccinations are administered annually. Secondary prevention is no less important once index cases of respiratory illness are detected. A crew member with respiratory symptoms may require a barrier-to-droplet transmission, such as a surgical mask.

Sea sickness is a major problem for new crew members and in high seas, and is aggravated in berthing or working spaces where sailors lose sight of the horizon. Whether a ship pitches or rolls, in cramped living spaces some of the racks will unavoidably orient in the axis of motion most conducive to sea sickness.

The loss of privacy aboard ship is terribly stressful to many people. The feeling of being only one of a multitude can threaten a young person's self-esteem and cause a paradoxical sense of loneliness. The psychological consequences of this kind of living are all the more threatening to immature sailors and those with personality or anxiety disorders.

The Ship's Cycle

A ship has a recurring cycle much like a living organism. The cycle's components include the following:

- **Pre-deployment testing and training.** Months before a ship departs on extended deployment, the crew runs a series of tests and training sessions to prepare for increasingly complex demands during underway periods. The first short outings teach the crew to work the ship's power and navigational systems. Longer cruises follow to test maneuvers, weapons, communications, and tactics. Finally, periods at sea are spent coordinating with other ships in the task force, embarked amphibious forces, or other branches of the armed forces. Evaluations and inspections are held at each step to certify the ship's readiness to advance to the next phase.
- **Deployment.** The ship's mission or patrol (deployment) involves many months away from home. Because emergencies during deployment invariably entail cooperation among the ships traveling in a task force, medical aspects of mass casualty and damage control drills must be inserted into group deployment training plans and executed during the deployment.
- **Postdeployment maintenance.** On the ship's return from deployment, maintenance and minor upgrades are performed in the shipyard. This work may require only a few weeks for a small ship or 6 months for a large, complex ship such as an aircraft carrier.

- **Major overhaul.** After two to five complete cycles, the ship needs a major overhaul to implement technological advances and repair accumulated wear and tear. Large ships may require more than a year in the shipyard.

The crew also has a cycle. Because military crew members are assigned to a ship for periods of only 2 to 5 years, at least one-third of the crew turns over annually. After a long deployment and time in the shipyard, new crew members and incumbents must undergo extensive training; the entire crew may require new skills or training on new technology and tactics for a planned deployment.

The ship is an entirely different organism in each phase of its cycle. The medical problems of each phase differ too. In the shipyard, the ship becomes an intense, crowded, dangerous industrial plant. Ordinary ventilation, plumbing, and electrical systems are compromised. Passageways are crowded and cramped with people and equipment. Sandblasting, other respiratory hazards, paint, and solvents are everywhere. Welding aboard a ship causes fire risks and vision hazards. Grinding equipment creates hearing and ocular hazards. Workers are vulnerable to falling tools and metal objects; common injuries include head trauma, burns, crushed extremities, and lacerations. Workers unfamiliar with the ship can wander into unventilated spaces and die of asphyxia.

When the ship is underway, the safety of all systems must be checked, certified, and treated with great respect. New crew members are likely to trip over unfamiliar projections on decks and are vulnerable to falls down ladder wells and holds. Burns and lacerations are common; puncture wounds and wrist and ankle fractures occur too. New crew members encounter sea sickness, loneliness, cramped spaces, unprecedented stress, and long working hours. Depression, acting out, and suicidal gestures emerge as significant clinical problems. In addition, the medical department must implement a major teaching program to train all crew members in ship hygiene, first aid, cardiopulmonary resuscitation, locations of first aid boxes, and how to respond to a mass casualty, including the role of each crew member.

During the cruise, the ship is almost always deployed outside its home waters, away from families and domestic ports for several months. The medical department manages all of the ship's routine medical care, pursues required preventive medicine programs, maintains its own working and berthing spaces, and prepares to care for mass casualties even if major portions of the ship—possibly including the main medical department—are destroyed in battle. The medical department also manages the details of any necessary medical evacuations (MEDEVAC). Depending on the type of ship and its mission, port calls are often made to foreign nations, where the crew carries the home nation's culture and image to other peoples and is in turn exposed to the local culture—and its endemic diseases. Morale and readiness are usually at their highest at the early part of the cruise and before port calls.

SHIPBOARD OPERATIONAL MEDICINE DURING WARTIME

In naval warfare, medical care is limited to resources aboard the ship. If the decision is made that one ship has to assist another, its primary mission must be subordinated to transporting medical assets to assist another vessel. Assisting a disabled vessel during wartime effectively doubles the number of unavailable vessels to the operational commander.

Medical Care During Battle

As Captain Richard R. Cooper wrote in his article, "Medical Support for the Fleet,"[5] medical support during battle at sea assumes the following:

- Casualties are injured or wounded rather than killed.
- A ship that has been hit stays afloat long enough for the casualties to be medically managed.
- Medical personnel and equipment in the damaged ship remain functional.
- Treatment is focused on supporting those who are able to return to the battle.
- Transfer to another unit is feasible despite isolation of the ship, bad weather, or an ongoing battle.
- The receiving unit has medical capabilities, a place to hold the wounded, and the ability to treat or transfer them out of the battle area.

The delivery of medical care during battle is completely different from care during peacetime because saving the ship is the first priority. The two main threats to a ship's survival during combat are fire and flooding. More ships have been lost to fire and flooding than have been sunk by weapons. During general quarters (the ship's maximum readiness battle condition), ship compartments and air shafts are sealed to control fire and flooding. Damage control central coordinates and clears all movement to ensure air and watertight integrity and to minimize and control damage from

enemy missiles, torpedoes, shells, and mines. When enemy action or accidents damage the ship, repair parties (which are preassigned and trained) for specific areas of the ship respond to control the threat. Fire and flood threats are so great to the ship that the repair party will only move casualties to permit work in the damaged space. The injured are transported for medical assistance only after the threat is contained. A key factor that optimizes shipboard medicine performance during war is how well the ship's medical officers and enlisted personnel train the ship's crew to assist with first aid, litter carrying, and evacuation.

Shipboard battle casualties are unique in that they happen suddenly and in large numbers. Naval history teems with examples of what happens to a crew when a warship sustains sudden catastrophic damage. For example, on May 24, 1941, early in the Battle of the Denmark Strait, the Royal Navy battlecruiser HMS *Hood* was struck by several German shells, the magazine exploded, and the ship broke into two parts and sank within 3 minutes; only 3 crew members of 1,400 survived.[6]

In March 1945, the flight deck of the US Navy aircraft carrier USS *Franklin* (CV 13) was struck by two bombs, which exploded in the ship's hanger and detonated the *Franklin*'s aircraft ordinance and fuel. The resultant secondary explosions and fires destroyed the aft portion of the ship, killing 724 personnel and wounding 264. The main battle dressing station (BDS) was destroyed, and only one ship's doctor was able to care for the wounded (he later wrote an article on the realities of shipboard medicine during war).[7]

On July 29, 1967, the aircraft carrier USS *Forrestal* (CV 59) was off the coast of Vietnam, preparing to launch aircraft, when a Zuni rocket malfunctioned and set an A-4 Skyhawk aircraft afire on the flight deck. Within minutes several other armed aircraft caught fire and exploded (Figure 26-7). Dozens of flight crew and workers on the flight deck were instantly killed or severely burned. The fires and explosions extended down many decks, trapping and wounding more sailors in the messdecks and berthing areas. In all, 134 *Forrestal* sailors died, and several hundred others suffered severe burns, inhalation injury, and fractures. Figure 26-8 shows sailors on the *Forrestal* flight deck during firefighting operations. To handle the casualties, a staging and triage area was set up in the forward hangar bay and forward messdecks. The first casualties arrived in the main medical area within

Figure 26-7. Crewmen fight to extinguish the fierce blaze from airplanes burning on the deck of USS *Forrestal* (CVA-59) operating in the Gulf of Tonkin, July 29, 1967.
Reproduced from: https://www.history.navy.mil/our-collections/photography/numerical-list-of-images/nhhc-series/nh-series/USN-1124000/USN-1124780.html.

Figure 26-8. USS *Forrestal* crewmen direct a fire hose on burning aircraft on the carrier's deck while operating in Gulf of Tonkin, July 29, 1967.
Reproduced from: https://www.history.navy.mil/our-collections/photography/numerical-list-of-images/nhhc-series/nh-series/USN-1124000/USN-1124772.html.

TABLE 26-2

SHIPBOARD REQUIREMENTS FOR SPECIFIC MEDICAL EQUIPMENT

Medical Equipment per No. of Personnel	No. of Personnel
First Aid Boxes	
4/100	< 500
5/100	500
8/100	1,500–3,000
10/100	> 3,000
Stokes Litters	
1.5/100	< 1,500
3/100	1,500–3,000
4.5/100	> 3,000
Neil Robertson litters*	
N/A	0
Portable medical lockers	
1/250	N/A†
Battle dressing stations‡	
N/A	0

* One located adjacent to each vertical trunk, machine room, and shop space. The quantity is determined by the number of personnel occupying the space or compartment.
† Located adjacent to each repair party station.
‡ Quantity determined by class of ship; minimum: 2 (frigates) to 6 (aircraft carriers).
Adapted from: Riley, T. Shipboard medicine. In: Pandolf KB, Burr RE, eds. *Medical Aspects of Harsh Environments Volume 2*. Washington, DC: Borden Institute; 2002: 911.

10 minutes, and the operating room was in constant use for several days. The 53 beds in the medical ward quickly filled, so patients were treated in makeshift holding beds in the messdecks and berthing compartment. Major treatment areas also had to be set up in the forward battle dressing stations on the 0-3 deck just below the flight deck and in the forward messdecks. Most treated casualties were able to return to duty to fight the fires and perform damage control. The severely injured were forced to wait 5 days after the fire started for evacuation, which was when the tactical firefighting situation allowed flight operations. This event illustrates the importance of planning for and evacuating the wounded from a damaged ship[7] as early as possible.

The medical department places staff in BDSs throughout the ship in order to protect medical assets during a single hit. Moving medical supplies and litters from sick bay to the injured is not realistic; therefore, medical staff scatter portable medical lockers (also called "BDS in a box"), decontamination boxes, and litters throughout the ship as prescribed by Navy regulations shown in Table 26-2. Each BDS is equipped with a 50-gallon gravity-fed water tank, multiple battery-powered lanterns, emergency power backup, and communication lines. All communications and evacuations are cleared through damage control central first; the safety of the ship must take priority over individual medical care or everyone may perish. Maintaining watertight integrity and fire boundaries may require four litter bearers 20 to 30 minutes to move a single casualty 500 ft and the same amount of time to return.

Sinking, Immersion, and Survival

Despite the horrific nature of immediate, direct damage to ships in naval warfare, according to data from experiences of the Royal Navy[8] and US Navy,[9] 66% of deaths have occurred after the crew successfully abandoned a sinking ship. The main threat to a sailor's survival is the environment. The hazards associated with immersion are listed in Exhibit 26-1. If sailors are in lifeboats, the most critical survival items are food, water, and blankets. If sailors remain in the water, extra clothing may counteract hypothermia. However, water conducts heat 25-fold faster than air; and sudden immersion and exposure to cold induces a sympathetic reflex, which causes tachycardia, hypertension, tetany, and hyperventilation. At the same time hypothermia causes sailors to become lethargic and lose the ability to protect their airway and turn their backs to a choppy sea. A sailor's survival after abandoning a ship is dependent on the water temperature, sea state, swimming ability, and physical conditioning. According to Royal Navy data, most deaths from hypothermia occurred within the first 24 hours after immersion. But if a sailor survives the first 24 hours of immersion, the chances for survival improve dramatically.[8]

EXHIBIT 26-1

HAZARDS OF BEING SUNK AT SEA

Hypothermia
Drowning
Entanglement in or traumatic contact with a sinking ship
Inhalation of and contamination with fuel oil
Trauma from surfacing objects
Underwater explosions

Source: *Handbook for Royal Naval Officers*. London, England: Ministry of Defense, Medical Directorate General (Naval); July 1981. BR 2193.

The next greatest survival threat occurs shortly after survivors of a sinking ship are rescued. Sudden collapse and death have been observed, usually within the first 15 minutes of rescue, but occasionally up to several hours later. When the Argentinean cruiser *General BelGrano* was torpedoed and sunk during the Falkland War (1982), 71 survivors were rescued from life rafts; of those, 69 had hypothermia and 18 died of exposure. Both the Royal Navy and the US Navy have made recommendations for maximizing the survival of sailors who suffer from immersion. Exhibit 26-2 lists the Royal Navy's detailed recommendations.

After hypothermia, the next greatest survival threat at sea is the lack of potable water. The human body needs water for survival and the record for survival without water is 11 days. The Royal Navy found that water consumption of 150 mL per day was associated with a 22% mortality over a 6-day period. However, when water consumption was between 150 mL and 450 mL/day, the mortality was 0.6% for the same period.[8] The US Navy recently started putting reverse osmosis units like the Katadyn (Katadyn Group, Zürich, Switzerland) MROD-06-LL and the MROD-35-LL desalinators in liftrafts.[10] These reverse osmosis units squeeze salt water through a semi-permeable membrane fine enough to remove salt and other contaminants. The MROD-06-LL is an extremely small, hand-operated desalinator that provides one liter of fresh drinking water from seawater per hour. The larger MROD-35-LL is a 9-pound hand-operated pump that produces over 4 liters per hour.[10] In order to minimize evaporative loss from sweating in high temperatures, work should only be done during the coolest part of the day (in the early morning and late evening). A full moon may allow work parties to safely work at night. Clothing soaked in seawater can decrease sweating by 83%,[8] but clothing must dry before sunset to avoid heat loss at night.

Body fluids contain approximately 1% saline. The maximum concentration of salts in urine is 2%, half of which is sodium chloride and half urea. Drinking seawater increases the salt concentration in the body fluid, further aggravating dehydration. The only way to get rid of the excess salt is by sacrificing internal water. Additionally, mixing salt water with freshwater does not help because of the obligatory shift from intracellular to extracellular water. Both these scenarios hasten death.[8] Therefore, sailors are advised not to drink seawater or mix it with freshwater. Survivor mortality associated with seawater consumption is given in Table 26-3.

Amphibious Operations

Amphibious operations against a defended beachhead are the most arduous and dangerous type of military campaign. On the first day of an amphibious assault, the wounded in action rate can average 62.5 per 1,000 personnel.[9] Amphibious ships have more

EXHIBIT 26-2

CARE OF SURVIVORS OF VESSELS SUNK AT SEA

Assist survivors out of the water into the rescuing vessel*

- Conscious:
  - Never leave unsupervised for first 72 h
  - Prevent postural hypotension
  - Avoid alcohol consumption
  - Minimize ambulating to rewarming area
  - Rewarm survivors by seating them, clothed, under a hot shower, and gradually remove clothing†
- Unconscious:
  - Maintain the airway
  - Place under warm blankets after wet garments have been removed

Notes on near-drowning:

60% vomit during resuscitation

Pulmonary edema may occur between 15 min to 72 h after rescue from water

*During World War II, many sailors were lost when they attempted to climb up the net on the side of the rescue ship. The effort was too great; they fell back into the sea and were lost. Later, lifeboats were lowered and sailors were pulled into them and then hoisted aboard ship.

†There is currently no other accepted therapy for treating hypothermia.

Adapted from: *Handbook for Royal Naval Officers*. London, England: Ministry of Defense, Medical Directorate General (Naval); July 1981. BR 2193.

TABLE 26-3

MORTALITY ASSOCIATED WITH DRINKING SEAWATER

Seawater	No. of Life Craft Voyages	No. of Men	No. of Deaths	Died (%)
Drank	29	997	387	38.8
Did Not Drink	134	3,994	133	3.3

Adapted from: *Handbook for Royal Naval Officers*. London, England: Ministry of Defense, Medical Directorate General (Naval); July 1981. BR 2193.

medical assets and space than other ships to care for the high numbers of expected casualties from marine combat operations. The problem of caring for wounded patients aboard ships is that wounds require surgery, best handled by trained surgeons during the "golden hour" (first hour after injury). When one considers the facilities and personnel required to care for 50 seriously wounded patients, as well as for 100 patients with minor wounds, it becomes apparent that three medical officers with limited equipment, regardless of their talent, will be challenged to provide sufficient care for the high numbers of expected casualties.[11] With time for adequate planning, and support, medical resources can be re-programmed at the fleet headquarters surgeon level to augment an amphibious ship's medical department to handle the expected number of casualties.[9,11]

Casualty management requires advanced planning so mistakes, such as concentrating medical resources in one location, are not repeated. It is critical to consult with medical personnel before casualties are evacuated to ensure adequate medical assets are available at the arrival location. Casualties are triaged so that only those patients who are medically cleared[8,9,11] and deemed stable enough to make the trip are evacuated.

Today's Navy does not have sufficient medical resources dedicated to support amphibious operations. Additionally, with improvements in satellite communication and surveillance, the time it takes to recognize and respond to a threat has decreased dramatically, and the distance at which the US military can successfully intervene has correspondingly increased. Amphibious operations can commence suddenly with little time for the medical department to deploy wartime resources. The capability to launch amphibious operations beyond visual and radar range of the shoreline, also known as "over the horizon," brings new vulnerabilities. The accelerated pace and depth of modern military capabilities has increased demands on medical support to sustain military operations and to care for casualties from both military and civilian victims of a conflict.[12]

THE MEDICAL DEPARTMENT ABOARD SHIP

The term "medical department" may apply to one person and equipment on a small ship or as many as 70 people staffing a virtual hospital on a large amphibious ship. Regardless of size, the department is obliged to look after its own spaces, the personal needs of its members, and its budget. Every department also has to take a role in ship-wide business, which includes berthing arrangements, watch standing, cleaning passageways and common areas, scheduling meetings, and interacting with all other departments (eg, supply, deck, weapons, and navigation). On some ships, departments also share housekeeping chores such as preparing food, loading supplies, and painting.

Medical department spaces on virtually all ships are confined and constrained. Even on large ships, pipes, valves, and overhead structures intrude into the working spaces of every BDS, creating nooks and corners that are used to brace and store medical equipment. The medical team must familiarize itself with the layout and location of supplies and equipment. A ship overhaul sometimes results in improved medical spaces. Conversely, another department or a naval architect may suggest using medical space for nonmedical purposes. Although the change may benefit the ship's functionality, the MO must protect the ship's medical capability and ensure that the CO and executive officer (XO) clearly understand the consequences of any such change.

The Medical Officer's Line and Staff Roles

As in any military organization, the ship has both line and staff functions. Most department heads are line officers and usually report to the XO, who is second in command, is responsible for the ship's daily activities, and reports to the CO. Staff officers, such as the lawyer and chaplain, report directly to the CO to provide expert advice in matters that broadly affect the crew across department boundaries. The aggregate volume of directives and policies from higher authority is large, and the topics are frequently so technical that the CO, who is ultimately responsible for compliance, must rely on the department heads and staff officers to implement policy and advise of any shortcomings.

The head of the medical department fulfills both line and staff functions. This chapter refers to this person as the MO; however, an independent duty corpsman may

fill the role on small ships. The MO on any large ship serves as the chief of the medical staff, a position that requires medical training beyond residency as well as several years of practice, including hospital experience. The ability to interface with senior officers and other ship commands requires several years in the Navy and at least one prior tour at sea. In this role, the MO serves as a department head, a line officer role who reports to the XO. Although the MO's daily job is to run the medical department, the role of staff officer and advisor to the CO is often paramount because planning and preventive medicine are more important to the overall health of the command than medical treatment after the fact. The MO serves as the CO's eyes and conscience in medical matters and can deviate from medical directives when necessary and with the CO's knowledge. When medical resources fall short of the required standard of care, the MO must convince the CO or higher military authority to take corrective measures. An effective MO develops confidence and mutual trust with the CO and XO.

All actions aboard a ship have medical ramifications, which the MO understands only in the context of (1) the physical threats and stresses involved in naval operations and (2) a thorough knowledge of the ship. The MO must recognize when proposed operations might affect crew health, require extra medical attention, or threaten to exceed medical capabilities, and inform other department heads of these situations. A representative of the medical department is included in all interdepartmental conferences and planning sessions. Although many operational topics are classified or confidential, the MO always has a "need to know."

Medical staff must interact with their department counterparts for meals, casual conversation, and off-duty activities in order to build trusting relationships. MOs and chief petty officers should visit the bridge and all the ship's working spaces and observe how others do their jobs. The word "shipmate" denotes an abiding relationship unlike any other. Trust, esteem, reliance, compatibility—ingredients for the deepest kind of teamwork—are necessary to build a place for the medical department among all ship personnel. This process may be especially challenging on a small ship where the head of the medical department is a corpsman and other department heads are officers. In such cases, the corpsman must develop strong relationships with the CO and the XO to gain acceptance by other department heads.

Medical Staffing

The size and composition of the medical staff depends on the number of the crew and the ship's mission. As a rule of thumb, there should be one independent provider per 800 to 1,000 crew members, but at least one on every ship. On small ships, the sole provider is usually an independent duty corpsman, who is a senior petty officer with a minimum of 6 years of experience as a corpsman followed by a year of intensive medical training. On larger ships with several providers, three-fourths should be physicians. A ship with women onboard needs at least one provider with special skills in gynecological diagnosis.

Every shipboard medical provider needs to be proficient and certified in both Advanced Trauma Life Support[13] and Advanced Cardiac Life Support.[14] Falls, burns, and lacerations are frequent aboard ship and can require endotracheal intubation, emergency cricothyrotomy, insertion of chest tubes, diagnostic peritoneal lavage, and venous cut downs. Smaller ships do not have operating rooms, but larger ships like aircraft carriers and amphibious assault ships are fitted with a full operating room that is staffed by a general surgeon, an oral surgeon, and an anesthesiologist or a nurse anesthetist, as well as a qualified operating room nurse and at least two fully trained surgical technicians.[11]

Ships with continuous air operations and embarked aviation groups of squadron size or larger need a flight surgeon and at least one aeromedical technician. On aircraft carriers and amphibious attack ships, embarked aviation units bring their own flight surgeons. On an aircraft carrier, the senior MO is also an experienced flight surgeon. Destroyer, frigate, cruiser, and auxiliary ships with a one- or two-helicopter detachment rarely have a flight surgeon aboard; aviation personnel must obtain aeromedical services from other elements of the battle group.

An example of the complex organizational relationships aboard ship is the surgical team that usually embarks with an amphibious ready group. Although the surgical team reports operationally to the commander of the amphibious task force, it is administratively assigned to the ship's medical department. The team's credentials and privileges are managed by higher military medical authority, but they must also be reviewed and certified for the CO by the ship's MO.

The hospital ships USNS *Comfort* (T-AH-20) and USNS *Mercy* (T-AH-19) have the largest medical capacity of all US Navy ships[15] that can deploy to a theater of operations (Figures 26-9 and 26-10). These hospital ships are as tall as a 10-story building and as long as three football fields. Their primary purpose is to serve as a floating hospital that travels with the fleet; their secondary mission is humanitarian. These ships have a full complement of medical staff including surgeons, anesthetists, operating room nurses, technicians, and preventive medicine and environmental health

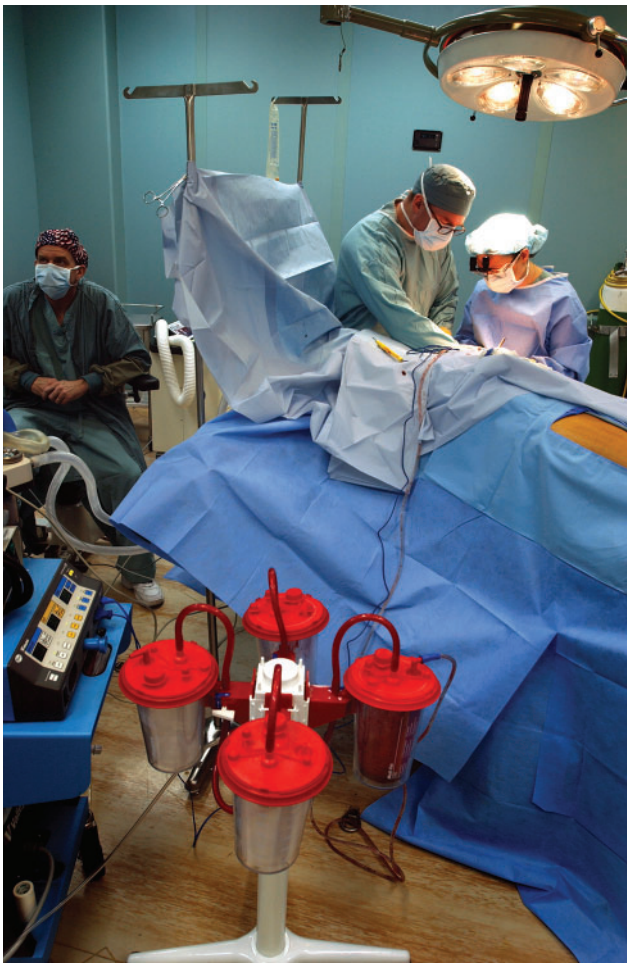

Figure 26-9. Surgeons operate on a patient aboard the hospital ship USNS *Comfort* (T-AH 20).
US Navy photo by Photographer's Mate 1st Class Shane T. McCoy.
Reproduced from: http://www.navy.mil/gallery_search_results.asp?terms=comfort+operating+room&page=3&r=4.

specialists.[15] In as little as 5 days, these ships can be converted from a skeleton crew into up to a 1,000-bed mobile hospital with a medical and support staff of 1,200.

Standards of Care

It was once acceptable to expect a lower standard of medical care in arduous, isolated environments such as military deployments or ships at sea than in fixed facilities. Throughout the 1980s, deployable medical systems in the US military were held to a standard called "austere but adequate," which meant the care was sufficient to preserve life and limb but implied "not quite as in civilian settings but good enough." Today, state-of-the-art medical care is the only standard acceptable to military patients, the Department

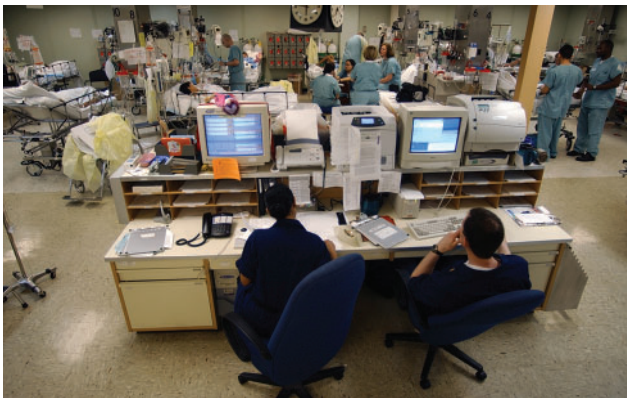

Figure 26-10. Corpsmen monitor heart rates of patients in the intensive care unit aboard the USNS *Comfort*.
US Navy photo by Photographer's Mate 1st Class Shane T. McCoy.
Reproduced from: http://www.navy.mil/management/photodb/photos/030423-N-6967M-090.jpg.

of Defense, and the US Congress. The expectation is that injured personnel who survive to reach medical attention will be healed, and that medical or surgical outcomes at sea will match the standards of civilian facilities. However, experienced military medical officers know that this not always possible in the austere environment of a ship at sea.

The ship's medical department must be able to handle all contingencies that could foreseeably occur during the mission, either by providing definitive care aboard or managing expeditious patient transport to more capable facilities. The medical department must ensure that the training of all medical personnel as well as sanitation and equipment in the medical department meet the standards of any medical facility of similar size at home. The department must be able to treat any illnesses or injuries or expeditiously and safely transport the patient to definitive medical care. If the medical department cannot meet the foregoing conditions, the MO must either take steps to remedy the situation or notify the CO. Although the CO has the authority to decide that military necessity overrides medical care, the MO must be sure the CO understands the potential consequences.

Credentials, Inspections, and Higher Military Medical Authority

The procedures for establishing credentials and delineating privileges for independent providers are the same as onshore and are usually managed by the fleet commander's medical staff.[11] Although shipboard medical departments do not require accreditation by

civilian agencies such as the Joint Commission for Accreditation of Healthcare Organizations, naval inspections at every phase of the ship's cycle resemble their civilian equivalents and are, in many regards, more stringent.

During shipyard periods, the Navy safety officer at the shipyard conducts frequent surveys of the ship's working conditions and environmental surveillance programs. Before beginning predeployment readiness exercises, the squadron medical officer and the ship's medical staff perform medical readiness assessments, which include checking the ship's medical equipment, storerooms, pharmacy, and condition of the medical spaces, as well as inspecting the crew's health records and the medical department's logs and training records. Medical providers on naval vessels must maintain and provide evidence of active state licensure as well as participation in continuing medical education to include basic and advanced life support. During the predeployment period, the fleet training group conducts a specific battery of evaluations and inspections called refresher training. For the medical department, this focuses particularly on how well the crew at large performs in first aid and mass casualty drills, the medical department's response to medical emergencies, and how well individual members of the medical department know the functions of all of the ship's other departments. At the end of the predeployment period, after preparation of the entire battle group, the fleet commander's medical staff conducts a thorough evaluation of all the ships in the battle group, rating the ships medical departments collectively in medical communication, patient transport and evacuation, and emergency preparedness.

Each administrative and operational command has its own medical staff, which periodically sends direction, guidance, and inquiries to the ship. Higher medical authority is expected to route communications through the ship's command channels. When direct communication occurs by phone or email between the MO and the fleet medical officer, the MO must inform both the XO and the CO of contact with higher medical authority. On those rare occasions when there is disagreement between the ship's command and guidance from higher medical authority, the MO must explain to their XO and CO the medical rationale for the decision-making. Nonetheless, if the MO cannot persuade the CO to adopt the medical viewpoint, the CO's decision prevails.

Education and Training for the Ship's Crew

The fleet or squadron medical officer inspects and evaluates the ship's medical department on crew performance in first aid and in mass casualty and MEDEVAC drills. Therefore the ship's MO must ensure that all crew members get training in CPR (cardiopulmonary resuscitation) and the resuscitation of an unconscious victim of electrocution. In addition, all crew members must know how to treat casualties for the "GITMO 8," a training series which covers treatment of the most common wounds and injuries likely to occur in a major explosion or fire.[16] Victims of these injuries can be saved by fast action; Personnel can use the skills they learn from the GITMO 8 to treat other traumatic injuries. The eight wounds are:

1. sucking chest wound (chest puncture with pneumothorax),
2. traumatic amputation of the hand,
3. maxillofacial trauma with compound fracture of the mandible,
4. abdominal wound with penetration of viscera,
5. compound fracture of the lower leg,
6. smoke inhalation,
7. burns; and
8. electrical shock.

Most ships have a closed-circuit television system, an invaluable way to spread medical and safety information. Many entertaining and understandable videos on medical topics are available. In addition, the MO should frequently have "call in" sessions to discuss current health topics such as the annual influenza vaccinations, illness outbreaks, or health issues in upcoming port calls. Notwithstanding the frenetic work schedule in all ship departments, medical staff should schedule frequent classes with small groups on subjects such as diet, hearing protection, responsible sex practices, prevention of unwanted pregnancy and sexually transmitted diseases (STDs), smoking cessation, substance abuse, and the importance of water consumption while at sea. The medical staff also provides health training for special occupational groups on the ship such as barbers, food handlers, and laundry workers.

PREDEPLOYMENT PLANNING

When a ship leaves the pier, it must have aboard all the medical resources the staff could possibly need throughout the deployment because operations or weather can prevent replenishment efforts. The MO and medical department must train, gather information, and plan well in advance because once the ship

is underway, the entire crew works 12- to 16-hour days, with full attention to the daily workload and operational events. General guidance to plan a medical inventory can be found in the *International Medical Guide for Ships*[2] and the *Handbook of Nautical Medicine*.[3] In the US Navy, the medical supplies each type of ship requires are listed in the Authorized Medical Allowance List. The minimum required stocks of medical equipment, medicines, and other consumable supplies is large; even for small ships, the list is dozens of pages long and contains thousands of items.

Nearly every action onboard ship carries health and medical consequences, yet line officers who are discussing tactics, weapons systems, or sailing plans may not realize the medical implications of those actions. For instance, certain operations may expose the crew to physiological hazards such as hypothermia and exhaustion, or the ship's route may impact MEDEVAC. The MO must recognize such problems and insist that other department heads consider this information in military and operational planning phases. The MO must also inform the CO when operational plans exceed the medical department's capabilities and the consequences of such situations. The CO may either adapt operational plans to reduce medical risks or accept the risks when they are balanced against other considerations. Such difficult decisions can only be made correctly with the MO's full counsel.

Many deployments involve a number of ships traveling in company. Destroyers or other ships with limited medical departments may be part of a task force that includes larger ships with extensive facilities. Under these conditions, potential interaction among the ships in the group must be carefully planned. Systems for medical consultation and communication should be exercised, as well as methods of patient transfer between ships.

Medical Intelligence

Medical intelligence can be used for both medical and military planning.[17] For medical planning, the MO gathers data about ports or countries the ship will visit. The MO interprets immunization campaign or disease outbreak information to help the operations and intelligence departments understand a nation's condition and its preparedness for war. This must be done well enough in advance to procure and administer immunizations and plan for such prophylactic measures as antimalarial medications and gamma globulin for protection from hepatitis. Intuitively, it seems that crew members should encounter infectious diseases only during port calls when they are ashore. However, the risk of disease has increased with the frequent use of aircraft for logistics, mail flights, and transport of visitors and replacement personnel. All new arrivals are potential infection carriers because they will have traveled through intermediate countries. In addition, crates and bags of vegetables brought aboard may carry rodents and insects. To take the necessary precautions, the MO must be familiar with endemic conditions in all areas of planned operation.

The main sources of medical intelligence for the Navy are the National Center for Medical Intelligence at Ft Detrick, Maryland, which is oriented toward biological and medical intelligence sources, and the Navy environmental and preventive medicine units, which focus on medical threats and health concerns for naval ships in a specific region. The two sources provide slightly different information. Early in the planning cycle and again immediately before departure, the MO must communicate directly with the Navy environmental and preventive medicine unit nearest the ship's planned area of operations and ask the theater or fleet medical staffs for information about recent disease outbreaks and epidemiology. Finally, the MO should seek information from medical representatives at embassies and consulates in nations where the ship expects port calls and near passage, although information from State Department sources is often less authoritative than from military sources.

Planning for Medical Evacuation

Every aspect of MEDEVAC must be planned and written into operating procedures before the cruise begins.[12] To begin with, the ship's medical staff must assess their capabilities and limitations and describe the patients that will need a MEDEVAC in their operating procedures. The MO should review MEDEVAC plans and notify the theater or fleet medical staffs of the ship's medical capabilities, so they know when to expect a MEDEVAC. All of these issues are then briefed to the CO and strike group commander. The CO must have a clear understanding of the potential risks to patients who may die because a ship's planned movements will take it beyond the reach of air transportation or shore hospitals so that MEDEVAC is not possible.

Crew Preparation and Screening

The first step in deployment preparation is to medically screen assigned personnel. Ships are hazardous and some people do not belong aboard: in an emergency at sea, one person's limitations or illness can put many crew members at risk. The *Manual of the Medical Department*[18] establishes physical and medical standards for sea duty. Vision and hearing are critical

to hazard awareness; although hearing aids and eyeglasses may be acceptable, crew members must be able to see well enough under poor lighting conditions to avoid injury while moving about and must be able to hear alarms even while asleep. Crew members must be agile enough to use the narrow passageways and steep ladders that typify military ships. A person with a chronic medical condition can be accepted for a cruise only if the medical department and its staff can manage the condition and its consequences.

Some classes of ships, such as aircraft carriers and amphibious assault ships, carry large numbers of embarked troops. Although they require the same immunizations and preparation as the ship's company, such troops are seldom available to the ship's medical department in advance. The MO must therefore arrange details early by communicating with the medical staffs of all commands that will embark troops. It is imperative that the XO or CO participate in this discussion because the ship could be at risk later if the command fails to insist on medical clearance before deployment.

Most military ships today embark numbers of nonmilitary personnel, including dignitaries and journalists on familiarization visits, technical representatives from industry, law enforcement agents, and educators under contract to teach college or vocational courses to crew members. These people, usually civilians, are easily overlooked by the medical department. Although they may not have the same physical requirements as sailors, they should be evaluated for mobility limitations and screened for chronic medical conditions that could lead to emergencies. Coronary artery disease is the most commonly encountered medical condition in this group of civilians.

The medical department must inform the command and entire crew of the need to acquire certain types of personal items well before going to sea. Most important are corrective lenses, medications not in the ship's formulary, and special clothing items such as shoe inserts or orthotics. These and other items that may be taken for granted at home may be difficult or impossible to obtain once deployed.

Contact lenses are not recommended for use at sea. Dust and fumes aggravate contact lens wearers, and crew members with long duty hours often forget to change contacts as advised, especially the long-wear and soft varieties. Crew members who use contact lenses must bring several pairs of them and sufficient supplies of cleaning and lubricant solutions for the duration of the cruise. Moreover, all crew members who require refraction, even if they use contact lenses, must bring at least two pairs of shatterproof, current prescription eyeglasses. Personnel who are required to wear safety glasses on the job must also bring two pairs. Eye injury treatment can be very limited depending on the size of the ship and medical department staffing.

Personality disorders are a serious cause of problems at sea.[19–21] Sailors with antisocial, narcissistic, and borderline type personalities who have acted out or required disciplinary action should be detached from the ship before deployment, because the incidence of suicidal gestures and disruptive behavior is so high among people with significant personality disorders. Unfortunately, these personality disorders are often not recognized until the combination of sleep deprivation, demanding work, and congested living cause enough stress to precipitate calamitous behavior. When such problems occur, the MO must persuade the command that although a personality disorder is not a medical illness, it is evidence of unsuitability for sea duty and that the sailor must be reassigned as soon as possible. A sailor with any prior suicide attempt should not go to sea except with the strongest supportive endorsement by a qualified military psychiatrist, preferably one familiar with sea duty stresses and limitations. Aircraft carriers have psychologists who will take the lead on these cases.

ENVIRONMENT IN THE SHIPYARDS, UNDERWAY, AND AT PORT CALLS

The environment aboard changes in significant ways during the various phases of the ship's cycle. Although the close spaces, noise, and high trauma risk remain constant, the training, work tempo, maintenance, industrial activities, and food service requirements differ. Predeployment operations allow for training and fine tuning of shipboard systems. In the deployment period, readiness and operations tempo put pressure on the crew and shipboard systems to perform at peak efficiency. This puts pressure on maintenance and operations departments to continue at this high operations tempo for long periods. During the postdeployment yard periods, the crew faces pressure to complete all required maintenance during the scheduled yard period. Crew exposures to heat, noise, dust, asbestos, chemicals, and radiation are markedly increased, which adds to the stress of being in the shipyard.

Traditional occupational and preventive medicine concerns are intertwined on a ship, because the crew lives in the workspace and because the same medical personnel are responsible for both preventive and occupational medicine programs.[22] The medical and safety departments are responsible for most prevention

and surveillance programs. For example, a ship may carry an industrial hygienist who is assigned to the safety officer but works closely with both occupational medicine and engineering personnel. The supply and preventive medicine departments share food service responsibilities; the engineering department oversees heat illness prevention, ventilation, and hearing conservation, while preventive and occupational medicine provides monitoring and related equipment, treats illnesses and injuries, and performs record keeping for occupational injuries and illnesses.

Heat and Noise

Engineers are primarily responsible for protecting the crew from heat stress and excessive noise; the medical department treats and monitors these conditions. It is easier to prevent both heat stress and hearing loss than it is to treat them after they have progressed. For instance, acoustical injury can be both cumulative and permanent—and heat stroke can be fatal. Thermal stress is a special problem on ships.[22]

Flight and weather decks may be exposed to severe heat and cold as the ship moves through different climatic zones. Heat, sun, and black painted metal decks often cause problems, which are amplified because all crew members on deck are required to wear protective headgear, long-sleeved jerseys, and flotation vests. The combination of intense work, high temperature, and protective garments causes overheating and dehydration. In addition, the work pace is so high that crew members must be reminded to hydrate; supervisors and corpsmen must frequently monitor flight deck workers to encourage fluid intake and watch for fatigue and signs of overheating.

The most common heat concern is excessive temperature and humidity below decks. Although modern ships have complex ventilation and air conditioning systems that reach most spaces, it is not possible to completely control the climate in engine rooms, galleys, sculleries, and laundries. Galleys are areas of insidious heat stress, with hot appliances and heavy workloads, and sailors work long hours in sculleries with high humidity and heat from hot water and dishwashers. Laundries also require special attention; dryers and pressing machines generate large amounts of heat, and ventilation may be inadequate, especially when equipment has been upgraded or the laundries occupy spaces originally designed for other uses. The operation of large equipment can create high heat loads in adjacent spaces where the work would not otherwise be stressful. For example, the steam catapults on aircraft carriers can raise the temperature and humidity in the layer of spaces immediately below the flight deck, which are occupied by offices, living spaces, and ready rooms.

The first steps in heat injury prevention are appropriate engineering design and insulation, but they can only be accomplished during ship construction or a major overhaul. Ventilation is more tractable and depends not only on fans and ducts but also on open doors, hatches, and scuttles. Under high heat threat conditions, when watertight integrity is required, doors, hatches, and scuttles must be secured, and the resulting decline in air flow can raise thermal stress to dangerous levels. The medical department can help prevent heat illness by visiting all shipboard spaces and seeing that sailors hydrate and avoid physical exhaustion.

Many medical emergencies are the result of heat-related injuries. The medical department is responsible for educating the crew about adequate hydration and heat stress prevention. In the engine spaces and flight decks, water loss can exceed 6 to 8 qt per day, so the importance of water intake must be constantly reinforced to the crew. The final step of heat stress prevention is to restrict exposure. The wet bulb globe temperature index is a measure of heat stress in direct sunlight. Corpsmen use wet bulb globe temperature readings to regulate work in hot environments and protect troops from heat injuries until they acclimate to the temperatures.[23]

Navy crew members can incur cumulative acoustical trauma that leads to hearing loss over many years. Individual hearing protection must prevent hearing loss or prevent the worsening of the condition. Audiograms should be obtained when the sailor first reports to the ship and performed annually thereafter. If the ship does have a sound booth and a hearing technician, then the medical department must schedule the crew for audiograms elsewhere.

Standards for required hearing protection are outlined in the many directives available to medical and engineering departments. Hearing protection is always required in engine spaces, flight decks, hangar decks, and machine shops; both internal and external devices may be necessary in the loudest environments. Crew members are especially at risk of hazardous noise exposure near aircraft platforms.

Isolation and Confinement

The ship environment at sea is, paradoxically, both crowded and isolated. The crew is packed close together without much privacy in living quarters, and they see the same faces during meals and at work. At the same time, people feel isolated because there are few

opportunities to communicate with family or friends back home. Time at sea means being away from land, vegetation, and most ordinary diversions. This is especially stressful for young people, many of whom are away from their families and homes for the first time. Common stress reactions include shortness of breath, insomnia, anxiety, depression, panic attacks, and prolonged sea sickness. Bedwetting is less common and headaches usually have other causes. Bedwetting and sleep parasomnias (ie, sleepwalking) are particular conditions that are not conducive to sea duty; materials on psychiatric symptoms and emergencies are useful when dealing with such conditions at sea.[20,21]

The ship's command must take measures to minimize psychological problems and to ensure that crew members will recognize stress symptoms in themselves and others. Otherwise, a young sailor who reports to sick call with symptoms and is told that the cause is stress may interpret this response as dismissive. The CO should address the psychological effects of confinement and isolation at captain's calls and in talks to the crew early in each cruise. Division officers and chief petty officers should bring up the topic early and often at daily muster in quarters.

Recreation and distraction are other ways to fight isolation and confinement. The command must make special efforts to promote vigorous exercise and recreational programs that focus on getting the sailors out of their berthing and working spaces. Most ships, other than submarines or mine sweepers, have decks or flight decks that permit jogging, basketball, and calisthenics. Group sports are valuable and provide vigorous interaction with crew members other than bunk mates or workers from the same shop, although injuries from such activities also cause a significant proportion of lost duty time.[24] Diverse interactions reduce the sensation of being trapped with only a small circle of friends. Movies and television provide views of land, communities, and automobiles, as well as diversion, but they are passive and can keep a sailor in the berthing area when it would be better to get away.

Historically, sailors looked forward to a daily tot of rum or grog, and some navies still allow small amounts of alcohol at mealtime. The US Navy strictly prohibits alcohol, and sneaking it on naval vessels is now quite rare. However, drinking on liberty (shore leave) can be a problem, and alcohol withdrawal can become a medical concern from the second day underway. Alcohol withdrawal must be suspected in sailors with new tremors, autonomic symptoms, insomnia, or seizures in the first few weeks at sea. All ships have an alcohol abuse counselor assigned with special training in recognizing and helping sailors with substance abuse problems. The counselor will identify sailors with potential substance abuse problems and request the MO to rule out other medical conditions including neurologic, endocrine, or psychiatric problems that might explain the sailor's symptoms.

Epidemiology and Epidemics

Information on epidemiology and methods to track disease outbreaks may be found in the *Manual of Naval Preventive Medicine*.[22] The *CDC Health Information for International Travel*[25] is also a useful resource. *Military Preventive Medicine: Mobilization and Deployment, Volume 1*, is also an excellent resource.[26] The most common outbreaks on ships are food-borne illnesses, respiratory diseases, and skin conditions. Waterborne illness outbreaks are less common and are more likely caused by chemicals than by infectious agents. Any infectious disease outbreak must be reported immediately to the surgeon of the fleet commander and the nearest Navy environmental and preventive medicine unit. Tracking outbreaks begins with a clear diagnosis or at least a detailed description of the symptoms and time course of the index case or cases. It is imperative to confirm that the problem represents physical illness, since in close environments, outbreaks of hysterical somatic complaints can spread rapidly and be just as devastating as physical illness.

Most food-borne outbreaks can be traced to food storage problems, mixing of foods that should be kept apart, and poor hygiene among crew members.[22] The main defenses are good personal hygiene among food workers, clean work spaces and equipment, and proper practices in the storage and serving of foodstuffs. Many ships have hand sanitizer stations, especially at or around the galley and heads. The most common food-borne outbreak symptoms are acute gastroenteritis with cramps and diarrhea. Medical personnel should be able to identify the food items, meal shift, and galley common to affected members by taking a careful dietary history from each crew member. Patients must be adequately hydrated; oral rehydration salts are preferable to intravenous fluids. Antispasmodic medications may help severe cases. It is usually impractical to identify specific bacterial or viral agents aboard ship; if bacterial culturing is available, it may be useful to identify the genera *Shigella*, *Salmonella*, or *Vibrio*, which can require antibiotics for effective treatment. Widespread use of antibiotics among the crew is seldom warranted.

The rapid spread of respiratory illnesses is fostered by closely confined quarters and compromised ventilation aboard ship; respiratory symptoms are among the most common reasons for sick call visits. Harsh contrast zones between cool–dry and hot–humid

spaces cause cough and local mucosal irritability, which can be so widespread as to both mimic infectious outbreaks and increase the crew's vulnerability to them. Although respiratory infections are usually mild and self-limited, influenza and tuberculosis are much feared at sea.[21] Despite the youth of a ship's crew, it is critical to vigorously enforce annual influenza vaccinations to avoid an epidemic. Secondary prevention of respiratory diseases is relatively ineffective because crew members are usually infectious before symptoms develop. There are often requests for cough suppressants and decongestants or antihistamines, none of which reliably hasten recovery and all of which may have side effects that can be dangerous on a ship. The most important measures are to provide bed rest for as many of the affected crew as possible, encourage high fluid intake, control air conditioning, and prevent cigarette smoke. Medical staff must resist the temptation to prescribe antibiotics to everyone with a cough unless there is good evidence of a susceptible pathogen. An antibiotic-resistant organism in a crew who will work together for the next several months can be more hazardous than delaying diagnosis and antibiotic treatment.

Pests and Vectors

External parasites, insects, and rodents are recurrent problems aboard ships, and their control is addressed in the *US Navy Shipboard Pest Control Manual*.[27] Scabies, lice, and other external parasites are best prevented by crew education and hygiene. Bathing and laundry standards are most important. Skilled preventive medicine technicians should frequently inspect berthing areas, with special attention to bed linens. There must be a high level of suspicion during sick call; any sailor who complains of itching or other skin symptoms must be disrobed and examined with particular attention to hairy areas and spaces between digits. Whenever a case is detected, the affected individual must be treated immediately and berthed in an isolated area such as the medical ward, if possible. All linen in the berthing compartment must be laundered immediately, and mattresses may need to be discarded.

Cockroaches thrive in the warm, damp areas of a ship and where nutrients are available. Cockroaches are controlled by detection and prevention measures. Traps are used for detection rather than eradication and should be placed and maintained in most heads and all food preparation areas. Storing and eating food in berthing compartments is prohibited and strictly enforced. Standing water and moisture should be eliminated by vigorous cleaning and by venting heads, galleys, and sculleries. Insecticide sprays add a margin of control, but are still only secondary to cleanliness and prevention.

Rodents are a serious problem aboard ships. Rats usually enter a ship in port areas where hiding spaces and litter are abundant. Preventative measures include vigilance at brow walkways and the installation of rat cones on ship's lines. Since rats can swim, preventive medicine technicians need to work with the deck department and local authorities to inspect the hull at the water line at least daily and preferably several times per day. Both rats and mice live in storerooms. Mice usually enter the ship in store crates, especially those of grain and flour products. All new stores should be inspected for breaks in containers and the presence of droppings. Stores should be stacked and arranged so that inspectors can see all areas where rodents might enter or hide. As with roaches, the main control measure is to deprive rodents of food by careful storage and by confining food and eating to mess decks. Rodents and other vermin are usually eliminated by traps and careful use of poisons. A severe or resistant infestation requires that certified technicians fumigate the area.

Hypoxic Spaces

A ship has many sealed or unventilated spaces that can become hypoxic or can accumulate toxic or explosive gases. For example, stored vegetables consume oxygen, so that whenever a worker goes into a food storeroom, someone must be on watch outside with oxygen breathing apparatus nearby. Crew members are trained to be aware of such hypoxic hazards, but civilian workers in the shipyards may open doors or bolted covers in the course of their work with fatal consequences.

Welding is a hazard that arises during the shipyard phase of the ship's cycle because it consumes oxygen at a high rate, and compartments where welding is done are often closed to forestall interruptions. Because welding requires a watcher in adjacent compartments in case a fire starts when heat is conducted through a metal bulkhead, the "firewatcher" should also be trained to monitor the welder for signs of hypoxia.

Flight Operations at Sea

Although aircraft carriers and large amphibious ships are well known for their flight operations, many other ships also have flight decks and carry one or two helicopters at sea. All the hazards inherent in military flight operations pertain at sea, including windblast, collisions, fires, and explosions. However, the naval environment aggravates some of these risks.[28] For the

flight crew, a failed landing—which runs an aircraft into the grass on land—produces a rapidly sinking metal coffin at sea, since jet canopies are difficult to open and helicopters that land in water invert and sink immediately, owing to the weight of their overhead engines. Jet blast can blow a sailor over the ship's side, and the fall from the flight deck—30 to 40 ft—can be incapacitating. Pneumothorax from impact, abdominal injuries, and hypothermia should be anticipated from any accident that puts a person in the water. Therefore, the ship's flight deck personnel must wear survival vests or jackets with a self-inflating mechanism, as well as locator beacons, sea dye markers, and shark repellant.

Although major mishaps with mass trauma and severe burns are a constant concern during flight operations, less dramatic injuries are more common and still dangerous. They include musculoskeletal injuries and fractures, eye trauma, contusions, lacerations, crush injuries, dehydration, and severe sunburn. Chronic fatigue and sleep deprivation can lead to absentmindedness. Medical crews need to be on the deck during flight operations to assist in rescue, and the main medical department assumes a high level of alert. On aircraft carriers and large amphibious assault ships, closed-circuit television allows the main medical department to monitor flight operations for immediate medical response to mishaps.

MEDICAL CARE AT SEA

Sick Call

Sick call is the daily period when the clinic is open for routine visits and treatment. Sick call is far more important on a ship than in other military settings, because minor problems must be treated early to keep them from worsening beyond the ship's treatment capacity. In addition, sick call provides over-the-counter medications, band aids, and other items a drugstore carries.

Sick call provides the most fundamental means for monitoring the crew's health. Complaint and injury rates vary with the ship's type and mission, the climate, the phase of the ship's cycle, and the time of year. During high operational tempo, sailors are less likely to frequent sick call for minor problems. At these times, members of the medical staff must walk through all work spaces to assess fatigue levels and target those who need treatment. Special efforts to encourage fluid intake are also necessary. The "sick list" is a daily report to the CO and XO that includes the number of sailors treated and their diagnoses. One of the most common sick call "prescriptions" is a note or "chit" recommending light duty or rest. Although the sailor's division officer or chief petty officer often honors such a chit, it is only a recommendation.

On most ships, sick call is open two or three times each day to accommodate working and sleeping schedules. Patients are usually seen first by junior corpsmen; a standard operating procedure details treatment for specific problems and lists those complaints that require a physician's or senior corpsman's attention. The MO must train the medical staff to appropriately triage the sick patients for conditions that need a higher level of care and to avoid turning away truly sick crew members. On large ships, many sailors gather at the clinic door for sick call and form a line that extends down the passageway. Medical department corpsmen should quickly screen complaints and see the most sick patients first, while others are given appointment times to return to the clinic. Crew members who need follow-up visits are asked to return after the second group. This allows crew members to stay at work and avoids long lines of patients outside the clinic.

Privacy is hard to provide on a ship but is essential in sick call. It is necessary to have a sign-in method that allows sailors to state their medical complaints where others cannot hear, and the sign-in log must not be visible to other patients. Because most sailors are reluctant to discuss medical history or emotional topics if they can be overheard, there must be a consultation room with a door that can be closed. Sick call is a haven for sailors who need sympathy or respite; they should feel that they can trust "the docs"—a term used for corpsmen as well as physicians—to provide a sympathetic ear as well as prompt treatment. Knowing that even minor aches and pains will be taken seriously and treated in a private, dignified manner is important to young people who have few distractions aboard ship and can be prone to worry about physical problems.

Some sailors come to sick call so often that they win a reputation as slackers or "sick bay commandos," and it is important for the medical staff to avoid becoming cynical or hardened to these sailors. When a large number of hypochondriacal complaints appear, it may well be the sign of a morale problem that is as important to the command as a physical illness outbreak. A physical illness may cause subtle symptoms for some time before it is evident on physical examination or laboratory tests. A patient who is dismissed or becomes discouraged at the first visit to sick call may not return until the illness worsens. Most importantly, crew members must trust the medical department if they are to be forthcoming about medical histories and

feel confident at times of emergency or personal crisis. While the medical department's goal is to return sailors to work and discourage hypochondriasis, it is far better to tolerate "sick bay commandos" than to build a reputation for skepticism or insensitivity.

Disposition of the Sick Sailor

The MO at sea must consider proper patient treatment in the context of both occupational and military requirements. To determine whether a sick or injured sailor can return to duty, the MO often visits the sailor's work area to better understand the nature of the job and workspace. Additionally, the MO considers the long work hours that accompany sea duty along with sleep deprivation and fatigue, which impair recovery. Bed rest, or "sick in quarters," is the oldest and most reliable treatment for many ills. The value of rest and repeat examination cannot be overemphasized for cases of nonspecific illness. Crew members with fever or general weakness, or who require intravenous fluid for any reason, should be berthed in the medical ward when possible. On some ships, the sick bay does not have ward beds or the number of patients exceeds berthing. Any sailor who is confined to sick in quarters status should have an attendant from the same department and berthing area. Medical personnel should visit the patient several times a day to record vital signs.

The maximum period a sick sailor can be kept on the ship is established by the theater evacuation policy and the ship's own predeployment plan. Even the most sophisticated medical department lacks the diagnostic capability of a hospital ashore, and an illness that eludes diagnosis or a sailor who cannot return to duty can be demoralizing to the crew, deprives the crew of a useful member, and consumes important resources. Medical staff must not allow indecision to tempt them into keeping a sick sailor beyond the predetermined time limit.

Telemedicine

Experience shows that corpsmen and young physicians do not seek consultation as often as they should, and they should be taught that consultation not only improves treatment but can also prevent unnecessary patient transfers and evacuations.[29,30] Voice communication is the first level of consultation among medical departments in a battle group. Even when a ship is steaming independently, satellite communication often allows consultation with physicians or specialists on distant ships or at major shore facilities. Procedures for medical communication may be specified in predeployment plans or arranged at need.

Satellite television transmission for medical use is available on an increasing number of ships. While the consultant cannot touch or palpate patients, the ability to interview them and see facial expressions adds great value. These medical systems can transmit electrocardiograms and include appliances for auscultation as well as otoscopic and ophthalmoscopic examinations. The image allows very good dermatological diagnosis and visualization of endoscopy. Also, many medical departments have an issued digital camera and can email jpeg images to specialists for review. These diagnostic steps can take place in real time to assist the isolated medical provider, even in emergencies.

Medical Evacuation

The best way to transfer a patient is from a pier. Because all forms of transportation at sea incur risk, and most are rough compared to land transportation, evacuation at sea is viable only when predetermined medical criteria are met, consultation and telemedicine have been fully exploited, and the transport risks are outweighed by the patient's needs.

In years past, transfer at sea was by Stokes litter or boatswain's chair on high-tension cable strung between ships. While Stokes are still ubiquitous on ships, the present stretcher of choice is the Reeves Sleeve (HDT Expeditionary Systems, Fairfield, VA). Today, patient transport at sea is usually by helicopter. Most military ships have landing areas; if not, the helicopter can hover over the deck and winch the patient aboard in a litter cage. However, the latter process is terrifying for most patients and can be a rough ride, so it should be used only when no other transport is available. When the patient can wait long enough for evacuation, the medical department contacts the fleet's medical regulating officer, who arranges for the best treatment facility, transportation, and itinerary. The possibility of a long stay, further transport, or even reassignment is predictable, so all medical and personnel records accompany the patient at the time of transfer.

Safety is the first consideration in preparing a patient for transport. A medical escort who is adequately trained in water survival must accompany the patient to provide in-flight care. The patient must wear a survival vest, preferably one that does not require inflation. An ambulatory patient should walk aboard the aircraft and strap in like any other passenger. Litter patients must be secured with straps that permit quick release in an emergency. Tubes for fluids or oxygen must not dangle where they can become entangled, and intravenous fluids and blood must be contained in plastic bags without air pockets. If the patient could not survive a crash or water landing at sea, then the transfer should be reconsidered.

Most patients sick enough to warrant evacuation should have supplemental oxygen, since even a low-altitude helicopter flight can drop the partial pressure of oxygen too low for a patient with blood loss or compromised pulmonary function. The medical escort should watch the patient wearing an oxygen mask for vomiting and aspiration. A pneumothorax must be vented through a chest tube attached to a flutter valve or other mechanism to prevent backflow. Neither inflatable casts nor military antishock trousers can be used because they will expand in flight.

Port Calls

The MO reviews local disease surveillance reports long before the ship approaches any port of call.[13] An advance party usually visits the port to handle diplomatic issues and arrange docking and replenishment. The advance party should include a medical representative; if that is not possible, the MO must consult with members of the advance party to ensure they gather the necessary information. General epidemiological information must be updated with particular attention to the following:

- current outbreaks of disease;
- incidence of tuberculosis, arthropod-borne diseases, malaria, hepatitis, and STDs;
- occurrence of any disease with antibiotic-resistant organisms;
- the capabilities and standards of local hospitals;
- local water purification standards;
- food and restaurant sanitation standards; and
- incidence of recreational drug use in the area.

Before allowing sailors to go ashore, the chief petty officer or division officers of every department brief their members. These briefings must include persuasive remarks about malaria prophylaxis, warnings about food and waterborne illnesses, and safe sex practices. Unless the MO is satisfied with food safety and potable water supplies, the crew is advised to avoid eating or drinking in the local economy and to take bottled water from the ship.

In areas with significant malaria risk, the MO should persuade the CO to either select an alternate port for rest and recreation or keep the crew aboard the ship. Crew members who are required to go ashore for operational reasons must follow strict measures to prevent malaria, including the use of insect repellant, long-sleeved garments treated with permethrin, mosquito nets when it is necessary to sleep ashore, and rigorous adherence to malaria chemoprophylaxis.[31] Because chloroquine-resistant malarial strains are spreading over the world, it is essential that the MO review current information.

On arrival in port, the MO must visit the nearest hospital to which crew members will be referred, if necessary. In this visit, the MO can assess the standards and capabilities of local medical practice and establish the method of payment for medical treatment ashore. The MO must also explain the ship's requirements and limitations to local providers so they will not overestimate the medical facilities and return sailors to the ship who should have been treated at the hospital.

Most STDs are contracted on shore. Sexual relations among crew members are forbidden. Educational programs that encourage abstinence, monogamous relations, and barrier (condom) protective measures are still the best ways to prevent STDs.

Special Medical Concerns Aboard Ship

Conditions aboard ship place many medical issues in a special context. The increasing numbers of women stationed aboard ships mean that medical departments must provide advice and care in areas of gynecology and obstetrics. The availability of highly capable, fully staffed operating rooms aboard large warships not only improves the level of available care, but also obligates staffs to provide colposcopy and other services for women. As shipboard medical environments adapt, there may be reason to reevaluate the propriety of performing elective surgery aboard instead of transferring patients to onshore hospitals. Other concerns include the implementation of a "walking blood bank" to support emergency transfusions at sea and the proper disposal of medical waste in an era of concern over protecting ocean ecology.

Medical Care of Women

Women have served on auxiliary US Navy ships as integrated members of the crew since 1978 and began serving aboard combat ships in 1994. The ability of a ship's medical staff to provide obstetrical and gynecological care must be consistent with the general level of medical and surgical care. The sole provider or corpsman should have knowledge regarding differential diagnosis, the effects of hormonal cycles, pregnancy hazards, diagnosis of pelvic pain and pelvic infections, and when consultation and transport are necessary. Larger ships with at least one physician—especially if more than 200 women are on the ship—should also have a provider such as a nurse practitioner who has specialized training in the care of women. Ships with personnel capable of

performing abdominal operations must have at least one provider aboard who is trained in colposcopy and vaginal ultrasound.

From the medical planner's standpoint, the primary issues concerning women's healthcare are:

- the availability of personal hygiene items (a supply department issue with health implications) and direction on how to properly dispose of them at sea;
- privacy for medical history taking, screening programs, and examinations;
- staff competence and proficiency in reproductive and routine gynecological care;
- equipment for appropriate gynecological examinations and procedures; and
- contraception and pregnancy.

Contraception should always be a concern for male crew members, but the personal significance and medical consequences of contraception are much greater for women.

Present US Navy policy permits women to remain assigned to sea duty for the first 20 weeks of pregnancy, as long as they remain within 6 hours of definitive gynecological, surgical, and obstetrical care. This limitation reflects the risks of spontaneous abortion and hemorrhage from ectopic pregnancy during the first 20 weeks.[32,33] The rule permits pregnant women to remain aboard on deployments in the Mediterranean and Caribbean, within several hundred miles of most coasts, and worldwide when assigned to a hospital ship. During the first 20 weeks, a pregnant woman should be able to perform her ordinary job, although women who do considerable bending and heavy lifting may need some duty modifications because they are at increased risk of musculoskeletal strain. A pregnancy more advanced than 20 weeks requires the sailor to be transferred ashore.

Babies should not be delivered on naval ships; however, women have been able to conceal pregnancy for many months, and some have gone into labor at sea. Therefore, on any ship that has women aboard, at least one member of the medical department should be competent to perform a vaginal delivery, including a low-forceps delivery, if necessary. Ships with an operating room should have a physician who is able to perform a cesarean section. Neonates cannot be properly managed on a military ship, so if a baby is delivered, the ship must return to port as soon as possible to disembark the mother and child at the pier. Evacuation by helicopter is a distant second choice, owing to difficulties with keeping an infant warm, performing resuscitation en route, and ensuring survival at sea in case of an aircraft mishap.

Elective Surgery

Many surgical operations are well within a large ship's capabilities, which carries a competent operating room, a qualified surgical staff, and modern anesthesia. Emergency operations that can be performed include appendectomy, repair of an acute or strangulated inguinal hernia, resection of perforated bowel, and a number of other urgent procedures. However, performing elective surgery is not recommended, particularly when the ship is within reach of a hospital.[34] This is because even the best medical department at sea lacks the capability of a hospital to deal with complications. On the other hand, the surgeon must practice to maintain skills through exercises. The debate over elective surgery continues because both sides have strong arguments; however, a fatality during elective surgery aboard ship is intolerable. Despite the great challenge to maintain surgical skills aboard ship, elective procedures should be delayed until they can be scheduled in a hospital on shore.

Competence for Duty Examinations

Sometimes a supervisor observes unusual clumsiness or poor work performance and suspects the sailor is physically impaired because of some form of misconduct or dereliction such as alcohol consumption, drug use, or late night activity. The supervisor may bring the sailor to the medical department for a formal examination to determine competence for duty. The formal examination is not a medical diagnosis and treatment, but rather a legal requirement for disciplinary or personnel action. Such an examination should be performed only on written order of the CO or a duly designated officer in the sailor's chain of command. The MO is expected to perform a clinical examination and state whether the crew member is physically able to perform duties. The MO will obtain blood and urine tests to check for alcohol intoxication, presence of drugs, and other incapacitating substances.

Depending on the ship's operating tempo, sleep deprivation may be another explanation for poor duty performance. The MO should order only those laboratory tests that are necessary to formulate a clinical conclusion. For example, if the sailor appears to be drunk and smells of alcohol, then a diagnosis of intoxication can be made without ordering a blood alcohol test. The MO may ethically provide a professional opinion as legal evidence, but the medical department does not perform legally binding blood alcohol or drug screens, and medical staff must not be placed in the role of investigators or enforcement agents.

Mass Casualty Situations

A mass casualty event is one in which the number and severity of injuries exceeds the medical department's capacity to care for them, so that response requires coordination throughout the ship and rationed care for the injured.[7] Although civilian triage is performed to preserve as many lives and limbs as possible, on a military ship the overarching goal must be to save the mission or perhaps the ship itself. Therefore, the priority is to return the greatest possible number of injured to their duties in order to keep the ship afloat and in action. All crew members assigned to moving or treating patients must thoroughly understand this rationale.

A mass casualty situation requires immediate removal of the injured from the scene to a clear area where they can be laid out for quick evaluation and triage. At the triage station, casualties receive initial first aid measures such as intravenous lines, pain medication, and dressings. Some of the injured who receive adequate first aid may be released directly from triage for return to duty. However, it is imperative that all patients are tracked and accounted for at all times.

Coordination is critical in any mass casualty situation. A senior member of the medical department must move immediately to damage control central (the station center where damage control is coordinated) to determine the best locations for triage, a staging area if required, and the main medical treatment site or BDS. These decisions must be coordinated from damage control central because it has the best information about the state of the ship; areas that have been damaged; and routes for moving patients when many doors, passageways, and hatches are secured for general quarters. Members of the medical department must know how to use sound-powered telephones, which use wire strung during the emergency, to bypass damaged communications and power systems. In addition, runners must be designated in advance from among the litter bearers; in case of complete communications failure, they carry messages, questions, and information among the triage, staging, and treatment sites and to damage control central.

Corpses

The disposition of human remains aboard ship is frequently misunderstood. Planning and a firm understanding of issues regarding human remains is important; if a death does occur, responsibilities and processes should be clear. The medical specialists complete the death certificate, ensure medical records are maintained properly, and ensure autopsy reports are completed accurately in a timely fashion. In operational and doctrinal terms, however, a human body is no longer a patient at the time of death. The management and transport of corpses is the responsibility of the supply officer who will arrange for the disposition of the body. The MO should direct all questions regarding body disposition procedures and inventory of coffins, refrigerators for corpses, transport boxes, and body bags to the supply officer.

The Blood Bank

A modern blood bank is simply not available at sea except on hospital ships and sometimes on large amphibious attack ships. Even carrying supplies of Type O, Rh negative blood is impractical for technical and logistical reasons. Artificial blood products that rely on human hemoglobin show progress but have not yet been approved by the US Food and Drug Administration for clinical applications. Severe blood loss at sea can only be treated by using blood donated by crew members. The term "blood bank" refers to a group of prescreened, registered crew members who volunteer that have a known blood type and Rh status and agree to give blood for emergency blood transfusions at sea.

Personnel in the blood bank are screened annually for syphilis, hepatitis B and C, HIV (human immunodeficiency virus), and tuberculosis. In addition to the blood testing, a medical history should be taken to exclude crew members who had malaria, leishmaniasis, or other blood-borne disease. A blood smear and complete blood count with differential should be obtained to exclude personnel with blood dyscrasias and hemoglobin variants such as sickle cell trait, thalassemia minor, or glucose-6-phosphate dehydrogenase deficiency.

Blood collected from crew member donations does not meet the standards of safe blood found in modern medical centers. For example, there is always a risk that a donor has acquired a pathogen such as hepatitis or HIV between the last set of tests and donation. While these risks may be unacceptable in any hospital in the United States, the situation is different underway. Blood donated by crew members is the only immediate source of large quantities of replacement blood when it is essential to preserve life and limb. Blood collection procedures must be rehearsed periodically while at sea.

Disposal of Medical Waste

In the past, ships disposed of all trash and refuse at sea; currently, only that which is biologically degradable and harmless to ocean ecology and the sea floor

is thrown over the ship's side. No plastic is disposed at sea and great efforts are made to limit the amount of plastic that is even allowed aboard. The Navy is concerned with how to limit the amount of, and how to handle, the seven classes of waste aboard ships:

1. human elimination products, which pass through commodes and sinks into the ocean at sea or into holding tanks in port;
2. garbage and food waste, which are thrown into the sea and can be safely devoured by marine life;
3. degradable trash, such as some paper, which is incinerated or dissipated safely into the ocean;
4. metal and other recyclable material, which must be stored and brought to shore for proper disposition;
5. hazardous materials, such as paint, chemicals, batteries, some plastics, and expired medications, which are stored and disposed of ashore by authorities or certified agents;
6. medical waste that contains specific medical and biological material, certain medicines, spent needles and scalpels, and all tissues, which are held in designated medical spaces until released to capable disposal agencies; and
7. infectious waste or material, which requires special handling by the medical department.

SUMMARY

A ship's organization, physical structure, and specific mission form its working environment. In turn, a ship's medical department is configured and staffed to meet the needs of a specific ship and its mission. Life at sea is demanding, and the ship environment often leads to preventable injuries and illnesses. A ship's MO works with other department heads to emphasize injury prevention and precautions. The MO serves dual line and staff roles. The line function involves running the medical department; the staff function involves informing and advising the CO and XO concerning medical aspects of military planning and the crew's overall health and morale.

Medical care aboard ship should meet the highest standards of practice. The MO is frequently inspected by higher medical authority within the Navy. When planning for deployment, the MO must know the medical capabilities of each deploying ship and its staff. The MO should also have familiarity with and access to deployment planning resources. Before departure, the crew is screened for acute and chronic medical conditions and receives necessary immunizations. Common medical problems that occur while underway include fatigue, psychological stress, foodborne illness, respiratory disease, and skin conditions. The MO can use sick call rates to monitor the health and well-being of the crew. Medical personnel may recommend light duty or bed rest for sick sailors, or these patients may be admitted to sick bay. Anyone who remains ill beyond a predetermined time limit must be transferred to a more capable medical facility.

Shipboard medicine has adapted to recent changes such as the inclusion of women on combatant ships. Basic gynecological care and the capability to deliver a baby, if required, is available on most ships. Large ships have true operating rooms and carry surgical staffs and intensive care facilities. Telemedicine has made it easier for the MO to consult with subject matter experts in the field when the patient has difficult-to-diagnose conditions. The surgical staff remain medically active through humanitarian missions, during port calls, and through coordination with other ships to address surgical needs. The medical department must take the lead in preparing the ship's crew for drills and mass casualty exercises. Other issues include the proper handling and disposition of corpses, the organization of blood donations, and arrangements for the proper disposal of medical waste.

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