Chapter 29

SHIPBOARD MEDICINE

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INTRODUCTION

The demands of the environment exert extraordinary influence on the practice of medicine at sea. Even at sea, medicine is still medicine: history and examination are necessary for diagnosis, use of diagnostic adjuncts must be weighed against resources, and treatment is based on universal principles of surgery and medication. And yet, being at sea is different. The stress of close living quarters, isolation, and a hazardous environment are unequaled short of space travel. The prolonged absence from home, community, and normal environment creates profound emotional stress. It 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 the control of contagion. It is also a unique industrial environment, which carries yet further medical 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 interact fully with all other departments for everything the ship or battle group may do.
- 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.

The demands of the environment exert extraordinary influence on the practice of medicine on a ship at sea. Although there are few books on shipboard medicine,[1,2] the US Navy's Virtual Naval Hospital (VNH) constitutes a comprehensive digital library of medical information tailored to the Sea Service. Its home page (http://www.vnh.org) lists the following topical headings: Common Medical Problems; Dentistry; Pharmacy; Health Promotion; Occupational and Environmental Health; Medical Intelligence and Medical Plannng; Procedures; First Aid; Textbooks; Administrative Manuals; MEDLINE and Medical Journals; Continuing Education; Professional Health Organizations; Palm Handheld Computer Medical Resources; and Navy and DOD Resources. Specific sources of information available through VHN will be cited below, together with relevant journal publications.

This chapter focuses on military surface ships; medical problems aboard submarines are substantially similar[3] and will not be addressed here. Medical professionals on cruise ships find that the care of large numbers of passengers mimics the caseload of civilian emergency medicine.[4]

Organization Aboard Ship

The ship as an organization has many of the same departments and key positions seen in other large military units. However, the traditions of the Sea Service and unique features of seafaring have evolved 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, he or she is a navigational expert. "First Lieutenant" is the title but not the rank 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. And the Captain of a small ship may hold a lower rank, such as commander.

The ship has a special document, the *Watch Quarter and Station Bill,* which assigns every crewmember to watch-standing rotations and to specific positions and duties for military action or emergencies at sea. The *Bill* for each department is posted where everyone can check it, and crewmembers are expected to memorize their own assignments and those of their buddies. Watch standing has special meaning at sea. Survival of the ship and its crew depends on the vigilance of the sailor on the watch in certain positions. 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 culture and responsibility of watch standing are immeasurably important in the Sea Service. They are important issues for the Medical Department as well, 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 for everything on a ship rests with the Captain, it is the responsibility of the MO to thoroughly assess the medical needs of a ship. 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 a hundred jet aircraft and several thousand crew-

members. Only through a thorough understanding of the ship, the ship's cycle, and its specific mission can the MO give the Captain necessary advice and optimize care of the crew.

There are as many types of ships as there are reasons for sailing on the oceans. Several classes of ship from the US Navy are described in Table 29-1; they have parallels in the navies of other nations. Ships of war are unique for their complex surveillance programs, training requirements, and dangerous environment. In many cases, the medical responsibility is not limited to the ship's company: an am-

TABLE 29-1

SOME 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.
Nuclear powered cruiser, CGN class; 8,000–10,000 tons	Anti–air warfare, surface patrol and combat, missle warfare	450–600	1 GMO, 3 corpsmen (1 IDC), 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, CV and CVN (nuclear power) classes; 75,000–92,000 tons	Tactical aircraft, ASW helicopters, power projection and joint operations	> 5,300	6 MOs (1 a general surgeon); 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 and LHD 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; VSTOL: vertical/short take-off and landing

phibious attack vessel may start with a crew of about 1,000, but when it embarks 2,000 Marines with 70 helicopters and jet aircraft, a larger Medical Department is required simply to take care of all the people aboard. Furthermore, when the ship enters amphibious operations, it becomes a hospital for ground troops, many of whom arrived on other ships.

Life on Board

From the time a ship is commissioned until it is decommissioned, it is never "turned off" or left unmanned. Personnel assigned to ships are surrounded by hazards at all times as they work, eat, and sleep. Hazards on deck include helicopters, cables, fuel lines, and other items (Figure 29-1). Excessive heat and noise pervade the engineering spaces, boiler rooms, and machinery compartments. Steam pipes present the threat of asbestosis from insulation and danger from the steam itself if the pipes break. All kinds of equipment constitute electrical hazards. Toxic fumes and materials are ubiquitous from welding, paints, batteries, and even the mercury used by the Dental Department for fillings.

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

The sailor's only private place is his or her rack; most ships have curtains that can close off each rack for further privacy and darkness. Racks are usually arranged in rows that form small, roomlike 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

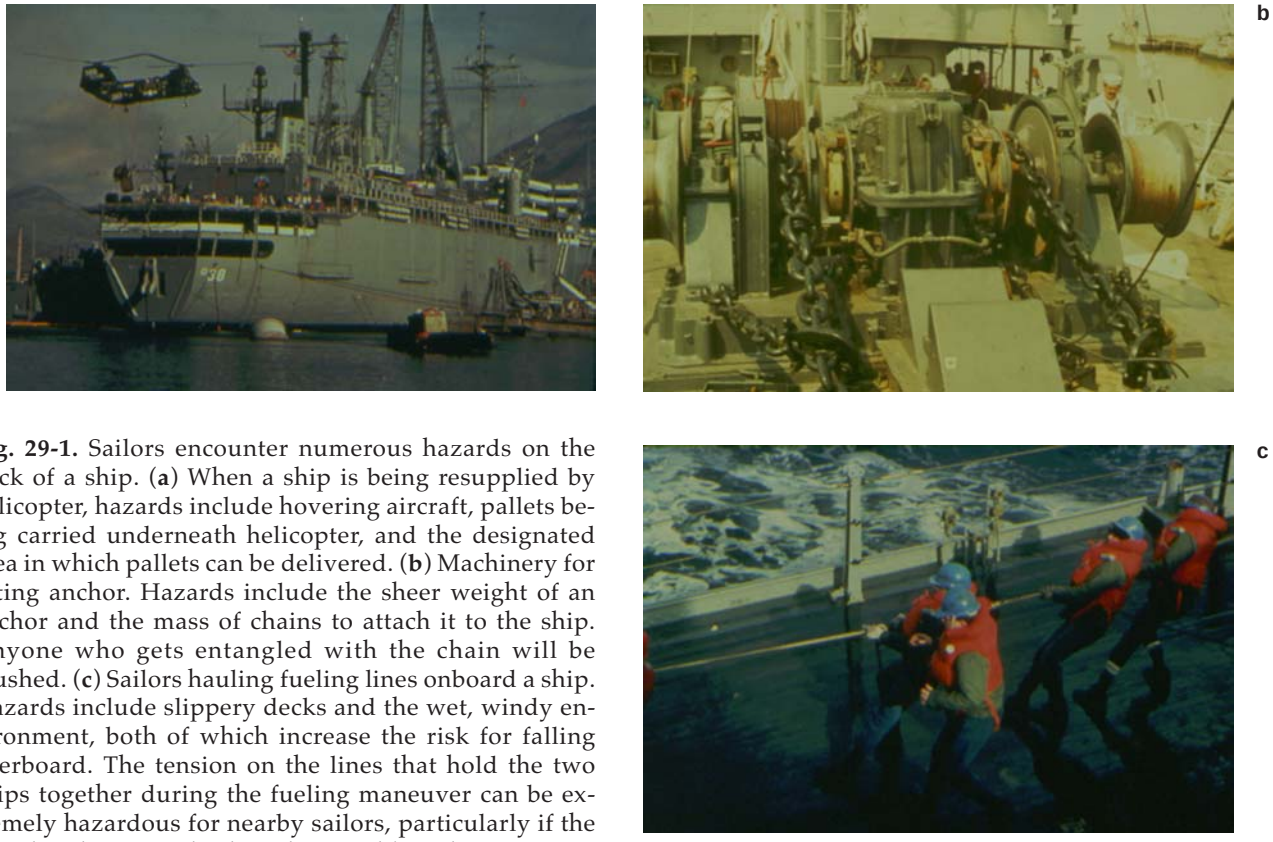

Fig. 29-1. Sailors encounter numerous hazards on the deck of a ship. (**a**) When a ship is being resupplied by helicopter, hazards include hovering aircraft, pallets being carried underneath helicopter, and the designated area in which pallets can be delivered. (**b**) Machinery for lifting anchor. Hazards include the sheer weight of an anchor and the mass of chains to attach it to the ship. Anyone who gets entangled with the chain will be crushed. (**c**) Sailors hauling fueling lines onboard a ship. Hazards include slippery decks and the wet, windy environment, both of which increase the risk for falling overboard. The tension on the lines that hold the two ships together during the fueling maneuver can be extremely hazardous for nearby sailors, particularly if the lines break or snap back: sailors could easily sustain severe injuries, such as amputation or decapitation from the lines. Photographs: Navy Imaging Command, Anacostia Naval Air Station, Washington, DC. Figure legend: Courtesy of Louis Kroot, MD, Department of Emergency Medicine, University of Kentucky Chandler Medical Center, Lexington, Ky.

clock, invariably some crewmember is beginning a watch or regular work duties in the middle of an adjacent shipmate's sleeping period. This traffic adds to the already difficult challenge of sleep hygiene and accommodation to schedules.

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, projecting ship fittings, and other sailors. Simple daily events such as dressing are made difficult when the 6 to 12 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 utilization can overwhelm the ventilation in those compartments. If showers do not dry between uses, fungi, soapy residue, and bad odors accumulate; sailors then avoid the bad shower and begin using one in a different area, driving up the use there so that it, too, will be overwhelmed.

Tight living conditions have obvious health implications. Many jobs on the ship cause sweating during exposure to petroleum products and dirt. Prevention of eczema and contact dermatitis requires clean, dry garments, yet clothing and boots do not dry well in crowded spaces. Lice and other parasites are a constant threat. So clean garments become a more important issue at sea than under other circumstances, and the crew must have frequent and ready access to laundry service.

Primary prevention is critical for diseases spread by respiratory routes or personal contact, which can infect dozens of sailors within a few hours. An outbreak of influenza could be rapidly devastating, so vaccination of the entire crew must be done yearly. Secondary prevention is no less important once index cases of respiratory illness are detected. Whenever possible, a sailor with even mild respiratory disease should be admitted to the medical ward. Barriers to droplet transmission, such as surgical masks, may sometimes be required for sailors with respiratory symptoms.

Sea sickness is a major problem for new crewmembers and in high seas, and is aggravated in berthing or working spaces where sailors lose sight of the horizon. In the cramped living spaces, whether a ship pitches or rolls, some of the racks will unavoidably be oriented in the axis of motion most conducive to sea sickness (for further information, see Chapter 35, Motion 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 components of the cycle include the following:

- Workups. The term "workups" denotes the formal process of testing and training that occurs in the months before a ship departs on extended deployment. Workups consist of a series of underway periods that make increasingly complex demands on ship and crew. The first short outings teach the crew to work the ship's power and navigational systems. Longer cruises follow to test maneuver, weapons, communications, and tactics. Finally, periods are spent at sea coordinating with other ships in the task force, embarked amphibious forces, or other branches of the armed forces. At each step, evaluations and inspections are held to certify the ship's readiness to move on to the next phase.
- Deployment. The ship's mission or patrol, deployment involves many months away from home port.
- Maintenance. On the ship's return from deployment, maintenance and minor upgrades are performed in the yard. 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 yard.

The crew also has a cycle. Because military crewmembers are assigned to a ship for periods of only 2 to 4 years, at least one third of the crew turns over every year. Extensive training is necessary for new crewmembers and for incumbents after a long deployment and a time in the yard; new technology and tactics for a planned deployment may require new

skills for the entire crew.

Like a moth and a caterpillar, the ship is an entirely different organism in each phase of its cycle. The medical problems of each phase differ too. In the yard, 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 being done all over the ship causes risks of fire and hazards to vision. 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 goes to sea for workups, the safety of all systems must be checked, certified, and treated with great respect. New crewmembers 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 fractures of wrists and ankles occur, too. And new crewmembers encounter the problems of life at sea: sea sickness, loneliness, cramped spaces, unprecedented stress, and long working hours. Depression, acting out, and suicidal gestures emerge as important clinical problems. In addition, the Medical Department must implement a major teaching program to train all crewmembers in ship hygiene, first aid, cardiopulmonary resuscitation, the locations of first aid boxes, and their mass casualty roles.

During the cruise, the ship is almost always deployed outside its home waters, away from families and domestic ports for several months. Although the pace of activity during a cruise is often less harried than it was on workups, the atmosphere is more serious because action is imminent. The Medical Department must manage all of the ship's routine medical care, pursue required preventive medicine programs, maintain its own working and berthing spaces, and be prepared 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 must also manage the details of any necessary medical evacuations. 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.

THE MEDICAL DEPARTMENT ABOARD SHIP

The term "Medical Department" may apply to one person and his or her 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 shipwide business, which includes berthing arrangements, watch standing, cleaning passageways and common areas, scheduling of meetings, and interacting with all other departments (eg, supply, deck, weapons, and navigation). In some ships, departments also share housekeeping chores such as preparing food, loading supplies, and painting.

The Medical Officer's Line and Staff Roles

As in any military organization, the ship has both line and staff functions. Department heads are line officers and usually report to the Executive Officer (XO), who is second in command and responsible for the daily activities of the ship. Staff officers such as the lawyer and chaplain report directly to the Captain to provide expert advice in matters that affect the crew broadly across department boundaries. The aggregate volume of directives and policies from higher authority is staggering, and the topics are frequently so technical that the Captain, who is ultimately responsible for compliance with all of them, must rely on the department heads and staff officers to carry them out and to advise him of any shortcomings.

The head of the Medical Department is unique in fulfilling both line and staff functions. In this chapter we will refer to this person as the Medical Officer, although that role may be filled on small ships by an Independent Duty Medical Corpsman, a Physician's Assistant, or a Nurse Practitioner. Although the MO's daily job is the line function of running the Medical Department, the staff role is often paramount, because planning and preventive medicine are more important to the overall health of the command than is medical treatment after the fact. The MO must serve as Captain's eyes and conscience for medical matters and must have the trust of the Captain to deviate from medical directives when

necessary, but should always notify the Captain when that happens. Doing this effectively requires that the MO develop a solid relationship of confidence and trust with both the Captain and the XO.

Everything the ship does has medical ramifications, which can be fully understood by the MO 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 be prepared to recognize and point out to the heads of other departments when proposed operations might affect crew health, require extra medical attention, or threaten to exceed the ship's medical capabilities. A representative of the Medical Department must be included in all interdepartmental conferences and planning sessions. Although many operational topics are classified or confidential, the MO always has a "need to know."

To build relationships of mutual confidence, members of the medical staff must mingle with their counterparts in other departments for meals, casual conversation, and off-duty activities. MOs and chief petty officers (CPOs) should visit the bridge and all working spaces on the ship as often as possible, and study 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 others on the ship. This process may be especially challenging on a small ship where the head of the Medical Department is a corpsman and all the other department heads are officers. In such cases, the corpsman must develop strong relationships with the Captain and the XO to gain acceptance by other department heads.

Medical Staffing

The size and composition of the medical staff depend on the number of the crew and the mission of the ship. As a rule of thumb, there should be one independent provider per 800 to 1,000 crewmembers but at least one on every ship. On small ships, the sole provider is usually an Independent Duty Corpsmen, 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 embarked needs at least one provider with special skills in gynecological diagnosis.

Every medical provider on a ship needs to be proficient and certified in both Advanced Trauma Life Support (ATLS)[5] and Advanced Cardiac Life Support (ACLS).[6] Falls, burns, and lacerations are frequent aboard ship and can require endotracheal intubation, emergency crichothyrotomy, insertion of chest tubes, diagnostic peritoneal lavage, and venous cutdowns. The presence on a small ship of intensive treatment spaces that resemble operating rooms does not imply true operating capability. On the other hand, an aircraft carrier is fitted with a full operating room 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.

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. Destroyers, frigates, cruisers, and auxiliary ships with a one- or two-helicopter detachment rarely have a flight surgeon on board, and 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 a Marine Amphibious Ready Group. Although the surgical team reports operationally to the Commander of the Amphibious Task Force, it is assigned administratively 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 Captain by the ship's MO.

The MO on any large ship serves as the chief of the medical staff, which requires medical training beyond residency as well as several years of practice including bona fide hospital experience. The ability to interface with senior officers and other ships requires several years in the Navy and at least one prior tour at sea. These are responsibilities of being the department head, in which role the MO reports to the XO. It bears repeating that the role of staff officer and adviser to the Captain, although requiring fewer hours, is often more important to the command and also requires years of naval experience. When medical resources fall short of supporting the required standard of care, the MO has the demanding task of convincing the Captain or higher military authority that corrective measures must be taken.

Standards of Care

It was once accepted that arduous, isolated environments such as military deployments or ships at sea could function at lower standards of medical care than those in the home community. Throughout the 1980s, deployable medical systems in the US military were held to a standard called "austere but adequate," which meant sufficient to preserve life and limb without frills. Not much insight is needed to recognize that this really implied "not quite as good as in civilian settings but *good enough*." Today, the only standard acceptable to military patients, the department of defense, and the US Congress is the state of the art. The expectation is that injured or diseased 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 widely held, experienced professional military medical officers know that this outlook is naïve and utopian. Therefore, it is incumbent on the military medical services that they help educate members of congress, journalists, and the public regarding the limitations imposed by the combat environment. We must ensure that the populace and its leaders understand that the austere military surgical and medical capabilities on a battlefield—on land and at sea—are far different from those at a civilian Level 1 trauma center.

The ship's Medical Department must be able to handle all contingencies that could foreseeably occur in the mission, either providing definitive care on board or managing expeditious transport of patients to more capable facilities. The Medical Department must assure 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 in the home community. The department must be able to treat—at contemporary standards—any illnesses or injuries—or be able to expeditiously and safely transport the patient to a capable medical facility within a timely interval. If the foregoing conditions cannot be met, the MO must either take steps to remedy the situation or notify the Captain of the deficiency. Although the Captain has the authority to decide that military necessity overrides concerns for medical care, the MO must be sure that the Captain understands all the potential medical consequences.

Credentials, Inspections, and Higher Military Medical Authority

The procedures for establishing credentials and delineating privileges for independent providers are the same as on shore and are usually managed by the medical staff of the Fleet Commander.[7] 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 Naval Occupational Safety and Health Agency makes frequent surveys of the conditions and surveillance programs on the ship. Before beginning workups, the Squadron Medical Officer and the Type Commander'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 health records of the crew and the Medical Department's logs and training records. Providers on naval vessels must document their active state licensure as well as currency in continuing medical education and life support. During workups, 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 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 workups, after preparation of the entire Battle Group, the Fleet or Type Commander's medical staff conducts a thorough evaluation of each ship's individual Medical Department together with coordination throughout the Battle Group, including medical communication, patient transport and evacuation, and emergency preparedness.

Many layers of oversight affect the Medical Department. Each administrative and operational command has its own medical staff, which periodically sends direction, guidance, and inquiries to its ship. Of course, such higher authority is expected to route communications through the ship's command channels. However, telephone lines in port and satellite transmission at sea allow direct contact between the MO and medical authorities outside the ship; while such communications surely improve medical care, the MO must inform both the XO and the Captain of contact with higher medical authority. On those rare occasions when there is incompatibility or disagreement between the ship's command and guidance from higher military medical authority, the MO faces a difficult dilemma: professionally, he or she may be inclined to side with superior medical officers; nonetheless, if the MO cannot persuade the Cap-

tain to adopt the medical viewpoint, the Captain's decision prevails.

Education and Training for the Crew

In the many inspections and evaluations by higher authority, the Medical Department is graded on how the entire crew performs in first aid and in mass casualty and medical evacuation drills. All crewmembers must be trained in CPR and the resuscitation of an unconscious victim of electrocution. In addition, all must master the treatment of the "Five Basic Wounds," which were chosen because they are severe injuries that are likely to occur in a major explosion or fire[8] and because victims can be saved by fast action. In addition, the skills involved can be used for all other traumatic injuries. The five 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, and
5. compound fracture of the leg or ankle.

Most ships have a closed-circuit television (CCTV) system, an invaluable way to spread medical and safety information. Many entertaining and understandable video tapes 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, outbreaks of illness, 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 intake 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

Predeployment planning is the critical test of the MO and the Medical Department. When the ship leaves the pier, it must have on board everything the medical staff could possibly need throughout the deployment. Training, information gathering, and planning must be accomplished in advance, because once the ship is under way, the entire crew works 12- to 16-hour days, with full attention required by daily workload and rapidly unfolding events.

General guidance on planning a medical inventory can be found in the *International Medical Guide for Ships*[1] and the *Handbook of Nautical Medicine*.[2] In the US Navy, medical supplies required for each type of ship are listed in a document called the *Authorized Medical Allowance List*. The required stocks of medical equipment, medicines, and other consumable supplies are staggering; even for small ships, the lists run to dozens of pages and thousands of line items. Predeployment planning includes advance knowledge of locations where medical resupply can be obtained if the need arises. Nevertheless, the Medical Department must be fully stocked before deployment because even if the ship will be in a part of the world where needed items should be available, replenishment can be prevented by operational necessity or weather.

Nearly every action of the 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 activities. For instance, certain operations may require exposing the crew to physiological hazards such as hypothermia and exhaustion, or the ship's routing may reduce the possibilities for medical evacuation. The MO needs to recognize such problems and insist that this information be considered by the other department heads in all military and operational planning. The MO must also be able to tell the Captain where proposed operations may exceed the Medical Department's capabilities and the foreseeable consequences for the crew. The Captain may then either adapt operational plans to reduce medical risks or decide that they are acceptable when balanced against other considerations, but such difficult decisions can only be made correctly with full counsel from the MO.

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. During the yard and workup phases of the cycle, the MOs of the different ships in a battle group should get to know one another by name and training, and should exchange visits to acquire first-

hand familiarity with the facilities and equipment on the other ships in the group. If visits cannot be arranged, then it is imperative to engage in the fullest possible exchange of letters and direct telephone communication. Systems for medical consultation and communication should be exercised, as well as methods of patient transfer between ships. 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 training plans during workups.

Medical Intelligence

Medical intelligence can be used for both medical and military planning.[7] The MO should anticipate being called on to interpret information on immunization campaigns or disease outbreaks to help the Operations and Intelligence departments understand the condition of a nation and its preparedness for war. For purposes of medical planning, the MO gathers data about ports or countries that the ship will visit. This must be done well enough in advance to allow for the procurement and administration of immunizations, and plans for such prophylactic measures as antimalarial medications and gamma globulin for protection from hepatitis. Intuitively, it seems that ships should encounter infectious diseases only during port calls when crewmembers go ashore. However, the risk of disease has increased with the frequent use of aircraft for logistics and mail flights as well as transport of replacement crewmembers and visitors. All new arrivals will have traveled through intermediate countries and are potential carriers of infection. In addition, crates and bags of vegetables brought on board 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 US Navy are

1. the Armed Forces Medical Intelligence Center in Frederick, Maryland, which is oriented toward biological and medical sources of intelligence, and
2. the Naval Environmental and Preventive Medicine Units (NEPMUs), which focus on medical threats and health concerns for naval ships in a specific region.

The two sources provide slightly different information; the Medical Department must keep the latest compact disk issued by each. Early in the planning cycle and again immediately before departure, the MO must communicate directly with the NEPMU 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, information should be sought 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

Everything about medical evacuation must be planned and written into operating procedures before the cruise begins.[7] To begin with, the ship's medical staff must articulate the exact capabilities and limitations of their skills and equipment and decide what kinds of diseases and injuries, levels of severity, and numbers of patients would exceed their capacity and thereby trigger medical evacuation. The MO should obtain the medical evacuation plans prepared by theater or fleet staffs and should notify them of the ship's medical resources and when to expect it in their area. All of these issues must then be explained to the Captain, who needs to understand clearly the requirements of modern medical care and the limitations of his Medical Department.

If the ship's planned movements will take it beyond the reach of air transportation or to areas where shore hospitals offer limited care, the Captain must be given a clear understanding of the potential cost of inability to evacuate certain classes of patients for definitive treatment. He may then want to reconsider the plans for deployment.

Crew Preparation and Screening

Medical screening of assigned personnel is the first step in preparing the crew for deployment. Ships are hazardous and some people do not belong on board: in an emergency at sea, one person's limitations or illness can put many crewmates at risk. In the US Navy, the *Manual of the Medical Department*[9] establishes physical and medical standards for sea duty. Vision and hearing are critical to perception of hazards; although hearing aids and eyeglasses may be acceptable, everyone on the ship 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. Crewmembers 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 deal with the condition and the consequences of its deterioration over time.

Some classes of ships such as aircraft carriers and amphibious assault ships carry large numbers of embarked troops (see Table 29-1). Although they require the same immunizations and preparation as the ship's company, such troops are seldom available in advance to the ship's Medical Department. 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 Captain 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 crewmembers. 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 limitations on mobility and screened for chronic medical conditions that could lead to emergencies; coronary artery disease is the most frequent and most frightening example.

The Medical Department must make the command and the entire crew aware of the need to acquire certain types of personal items well before going to sea on workups. Most important are eyeglasses, contact 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 can be problematic in the dust and fumes encountered below decks, and crewmembers with long duty hours often forget to change contacts as advised, especially the long-wear and soft varieties. Crewmembers 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 crewmembers who require refraction, even if they use contact lenses, must bring with them 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 of those.

During both the yard and workup phases, sailors can seek medical attention ashore. It is critical that the Medical Department be aware of all diagnoses and treatments from either civilian or military sources. Sailors have a knack for seeking out forms of treatment unacceptable to the Navy or obtaining inappropriate medical counsel from providers (sometimes even in the military) who have no knowledge of shipboard conditions.

Personality disorders are a serious cause of problems at sea.[10–12] Sailors with personalities of the antisocial, narcissistic, and borderline types 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 often cannot be recognized until the combination of sleep deprivation, demanding work, and congested living cause enough stress to precipitate calamitous behavior. Whenever such problems are revealed, 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—ever—should not go to sea except with the strongest supportive endorsement by a qualified military psychiatrist, preferably one familiar with the stresses and limitations of duty at sea.

SHIPBOARD ENVIRONMENT IN THE YARDS, UNDERWAY, AND DURING PORT CALLS

The environment aboard changes in significant ways in the different phases of the ship's cycle. Although the close spaces, noise, and high risk for trauma remain constant, the work tempo, industrial activities, and food services differ. The psychological environment changes too, producing different manifestations among the crew.

The traditional concerns of occupational and preventive medicine are intertwined on a ship, both because the crew lives in the workspace and because the same medical personnel are responsible for both preventive and occupational programs.[13] The Medical Department shares responsibility for most prevention and surveillance programs with at least one other department. For example, if a ship is large enough to carry an industrial hygienist, he or she

is assigned to the Safety Officer but works closely with medical and engineering personnel. Responsibility for food service is shared by the Supply and the Medical departments; heat protection, ventilation, and hearing conservation are overseen by the Engineering Department, while the medical staff provides monitoring, related equipment, and record keeping.

Heat and Noise

Protection from both heat stress and excessive noise are primarily the responsibility of engineers, with help from the Medical Department for monitoring and treatment; both heat illness and hearing loss can be prevented far more easily than they can be treated. The differences are that acoustical injury can be both cumulative and permanent—and heat stroke can be fatal.

Thermal stress is a special problem on ships.[12] Weather decks and flight decks may be exposed to severe conditions of heat and cold as the ship moves through different climatic zones. However, the most common concern is excessive heat 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 their hot appliances and surprisingly high work loads, and sailors work long hours in sculleries with high humidity and heat from basins of hot water and dishwashers. Laundries also require special attention; large amounts of heat are generated by dryers and pressing machines, and ventilation may be inadequate, especially when equipment has been upgraded or the laundries occupy spaces originally designed for other uses. The operation of certain large items of ship's 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.

Appropriate engineering design and insulation of heat-generating equipment are the first steps in prevention, 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 conditions of threat when watertight integrity is required, many of these 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 spaces on the ship and seeing that sailors keep themselves well hydrated and avoid physical exhaustion. In the engine spaces and flight decks, water loss can exceed 6 to 8 quarts per day, so water intake has to be encouraged and its importance constantly reinforced to the crew. The final means of protection against heat stress is to restrict exposure; the Wet Bulb Globe Temperature Index is routinely used aboard ship. (Heat-related problems in military operations is the subject of the Hot Environments section of *Medical Aspects of Harsh Environments, Volume 1*.[14])

Naval crewmembers can incur cumulative acoustical trauma over many years. Individual hearing protection must take into account any existing hearing loss (1) so that extra protection can be prescribed as needed and (2) to document the hearing status of each member when assigned to the ship and again when they leave it. Audiograms should be recorded at the time of first reporting to the ship and at predetermined intervals during the period of assignment. If the ship does not carry audiology equipment and technicians, the Medical Department must diligently schedule audiograms elsewhere.

Standards for required hearing protection are outlined in the many directives available to medical and engineering departments. Engine spaces, flight decks, hangar decks, and machine shops always require hearing protection; in the very loudest environments, double protection with both internal and external devices may be necessary.

Isolation and Confinement

The environment on a ship at sea is, paradoxically, both crowded and isolated. The crew is packed close together without much privacy in their living quarters and they see the same faces day after day during meals and at work, never able to get away. 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 the young people on naval vessels, many of whom have left their families and homes for the first time. Common reactions include shortness of breath, insomnia, anxiety reactions, depression, panic attacks, and prolonged sea sickness. Bedwetting is less common and headaches usually have other causes. Materials on psychiatric symptoms and emergencies are useful at sea.[11,12]

The ship's command must take measures to minimize psychological problems and to ensure that crewmembers will recognize symptoms of stress 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 that as dismissive or disrespectful. The Captain 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 CPOs should bring up the topic early and often at daily muster in quarters.

The command's other tools are recreation and distraction. 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 to provide vigorous interaction with crewmembers other than bunk mates or workers from the same shop, although injuries from such activities also cause a significant proportion of lost duty time.[15] 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 is now quite rare on naval vessels. 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. The ship will have an alcohol abuse counselor who has special training in recognizing and helping with substance abuse problems, but he or she must call for medical evaluation of potential clients so that the MO can rule out neurological diseases, endocrine or metabolic disturbances, and psychiatric problems.

Epidemiology and Epidemics

Information on epidemiology and methods of tracking of disease outbreaks may be found in the *Manual of Naval Preventive Medicine*.[13] *Health Information for International Travel*[16] is also a useful resource. (*Military Preventive Medicine: Mobilization and Deployment*,[17] another volume in the Textbook of Military Medicine series, also contains information on these matters.) The commonest outbreaks on ships are food-borne illnesses, respiratory diseases, and skin conditions. Outbreaks of waterborne illness are less common and are more likely to be caused by chemicals than by infectious agents. Any outbreak of infectious disease must be reported immediately to the Fleet Commander and the NEPMU. Tracking of 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 and the mixing of foods that should be kept apart.[13] The main defenses are good personal hygiene among food workers, cleanliness of work spaces and equipment, and proper practices in the storage and serving of foodstuffs. The commonest symptoms are acute gastroenteritis with cramps and diarrhea. Taking a careful dietary history from each crewmember should enable medical personnel to identify the food items, meal shift, and galley common to affected members. Patients must be adequately hydrated; oral rehydration salts are preferable to intravenous fluids. Antispasmodic medications may be helpful for 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 closely confined quarters and compromised ventilation aboard ship foster the rapid spread of respiratory illnesses, and respiratory symptoms are among the commonest reasons for visits to sick call. Zones of harsh contrast 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 make the crew more vulnerable to them. Although respiratory infections are usually mild and self-limited, influenza and tuberculosis are much feared at sea. Primary prevention of tuberculosis consists of proper screening of the crew and an active program of skin testing.[12] Vigorous enforcement of annual influenza vaccinations is critical despite the youth of ship's crews, because epidemic influenza could put the

ship itself at risk. Secondary prevention of respiratory diseases is relatively ineffective because they are usually infectious before symptoms develop. There is often a clamor 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 smoking. The temptation to prescribe antibiotics for everyone with a cough must be resisted unless there is good evidence for a susceptible pathogen; fostering the emergence of an antibiotic-resistant organism in a crew who will work together for the next several months can be more hazardous than the effects of a judicious delay for diagnosis before starting an appropriate antibiotic.

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*.[18] 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 his or her 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; eating in the berthing compartments must be prohibited and the rule enforced. Traps should be maintained in most heads and in all food preparation areas, but it must be emphasized that the traps are intended for detection rather than eradication. Control of cockroaches is achieved by the elimination of standing water and moisture by means of vigorous cleaning and ventilation of 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 for ships. Rats usually get aboard in port areas with their abundant hiding spaces and litter. Vigilance at brow walkways and installation of rat cones on lines are the main preventive measures. 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. Mice usually enter the ship in crates of stores, especially grain and flour products. All new stores should be inspected for breaks in containers and the presence of mouse droppings. As with roaches, the main control of rodents on board is to deprive them of food by careful food storage and by confining food and eating to mess decks. Rats and mice both live in storerooms, especially where food is kept; stores should be stacked and arranged so that inspectors can see all areas where rodents might enter or hide. Rodents and other vermin can usually be eliminated by traps and careful use of poisons. If the infestation is so severe or resistant that fumigation is required, that can only be performed by certified technicians.

Hypoxic Spaces

A ship that 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. Crewmembers are trained to be aware of such hypoxic hazards, but civilian workers in the yards may open doors or bolted covers in the course of their work or simply to sneak off for a nap—with fatal consequences.

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

Flying 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 exaggerates some of these risks and adds some unique problems.[19] 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 side, and the fall from the flight deck—30 to 40 feet—can be incapacitating. Pneumothorax from impact, abdominal injuries, and hypothermia have to be anticipated from any accident that puts a person into the water. Therefore, everyone who works on the flight deck of a ship must wear a survival vest or jacket with a self-inflating mechanism, as well as locator beacons, sea dye markers, and shark repellant.

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, CCTV allows the main Medical Department to monitor flight operations for immediate medical response to mishaps.

Workers on the flight deck are exposed to extremes of wind and weather. Since any ship conducting flight operations turns into the wind to add lift for the aircraft, wind chill is a serious problem in cold climates. However, heat, sun, and the black-painted metal deck more often cause problems, which are amplified by the fact that all crewmembers on deck are required to wear protective head gear, long-sleeved jerseys, and flotation vests. The combination of intense work, high temperature, and protective garments causes overheating and dehydration. In addition, the pace of work is so high that crewmembers must be reminded to drink; supervisors and corpsmen must mingle frequently with workers on the flight deck to encourage fluid intake and watch for fatigue and signs of overheating.

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, and severe sunburn. Ubiquitous fatigue and sleep deprivation can lead to fatal inattention. The machinery on the flight deck is particularly dangerous. On aircraft carriers, arresting cables stretch across the deck to catch the tailhook from landing jets. A sailor whose foot is in the way of the cable when it catches an airplane or retracts suffers severe fractures of the ankle or leg; if those high-tension cables snap from a rough landing, the whipping action can slice off a limb or head. Tractors for towing aircraft, in the crowded on-deck environment, pose a significant hazard for colliding with deck workers. Steam catapults with their rapidly shuttling transoms are further sources of injury.

MEDICAL CARE AT SEA

The spaces assigned to the Medical Department on virtually all ships are confined and constrained (Figure 29-2). Even on large ships, pipes, valves, and over-

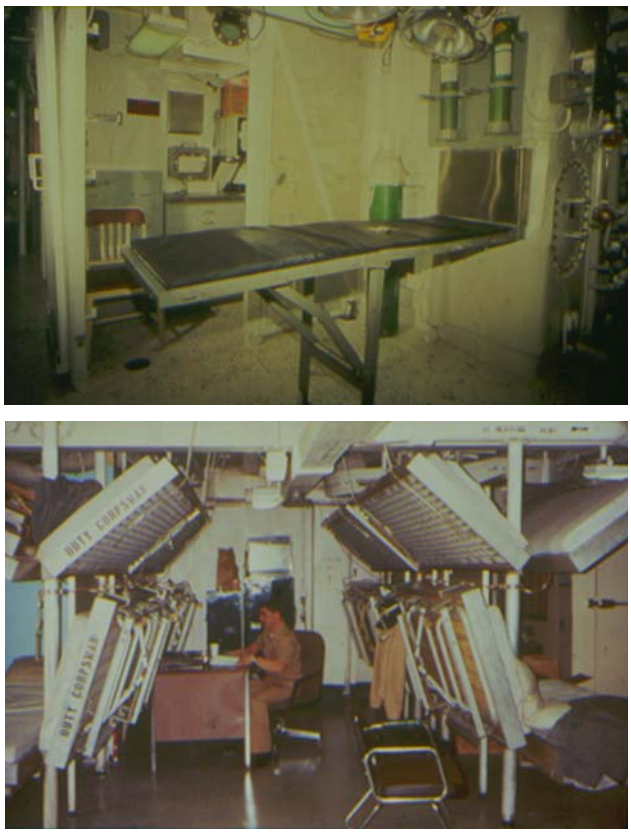

Fig. 29-2. (**a**) A battle dressing station is equivalent to an examination room in a hospital emergency department. The two small green canisters above and one large green canister to the right of the examination table contain oxygen. An emergency water tank to be used if power fails aboard the ship is located above the ceiling lamps. The yellow lights in the ceiling are also emergency lights that will be used in case of loss of power. Against the far wall is a portable suction machine and a wall-mounted autoclave (partially obscured). Below these are drawers where intravenous equipment, bandages, medicines, and surgical supplies are kept. Unless the ship is rigged for battle (ie, General Quarters), when not in use the examination table is folded flat against the wall, and the wire mesh partitions around the autoclave and drawers are closed and locked to prevent damage and pilferage. (**b**) Space is limited aboard a ship, and a physician's examining area may be an unused part of an inpatient ward. Unoccupied berths (beds) are folded toward the overhead (ceiling) to provide additional floor space. Photographs and figure legend: Courtesy of Louis Kroot, MD, Department of Emergency Medicine, University of Kentucky Chandler Medical Center, Lexington, Ky.

EXHIBIT 29-1

MOST COMMON MEDICAL PROBLEMS AT SEA

Abdominal pain
Asthma
Concussion/head trauma
Cutaneous abscess
Dermatitis
Fracture diagnoses and treatment
Gastroenteritis/vomiting and diarrhea
Hand injuries
Headache
Minor wounds and lacerations
Muscle strains/sprains/jams
Myocardial infarction
Pelvic pain
Personality disorder
Pharyngitis
Routine immunizations
Sexually transmitted diseases
Shoulder dislocation
Tooth abscess
Toothache
Upper respiratory infection

Adapted with permission from D'Alessandro DM, D'Alessandro MP, Hendrix MJC, Bakalar RS. Information needs of naval primary care providers and patients at sea. *Mil Med.* 1999;164(2):128.

head structures intrude into the working space in every battle dressing station (BDS), creating nooks and corners that are used to brace and store medical equipment. The medical team must become thoroughly familiar with the layout and the location of supplies and equipment to allow their rapid, efficient use when required. Ship overhaul may provide an opportunity to improve medical spaces, but it also may be the occasion for another department or a naval architect to suggest taking over medical space for nonmedical purposes. The change may indeed be necessary for the good of the ship, but the MO must protect the medical capability of the ship and be sure that the Captain and XO clearly understand the possible adverse effects of any such change.

Sick Call

Sick call is the period each day 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 must provide over-the-counter medications, band aids, and the like, which the sailor would find in a drugstore at home.

Rates of particular complaints and injuries vary with the type and mission of the ship, the climate, the phase of the ship's cycle, and the time of year (Exhibit 29-1). Sick call provides the most fundamental means for monitoring the health of the crew. The number of sailors treated and their diagnoses are reported daily to the XO and Captain in the "Sick List" or "Binnacle List," so named because historically the names of all sick sailors were posted on the ship's compass (binnacle) on the bridge. One of the commonest "prescriptions" from sick call is a note or chit recommending light duty or rest; although the sailor's division officer or CPO nearly always honors such a chit, it is important for both the medical personnel and their patients to realize these chits are not orders but only *recommendations* to the command.

Fig. 29-3. *Sick, Lame, and Lazy: Sick Bay Line Aboard USS Oriskany (CVA-34) During the Gulf of Tonkin, Aug 71.* Painting by Charles Waterhouse. With no chairs and no magazines to read, a long line of men waits for sick call; privacy is scarce to nonexistent. The title seems to reflect the artist's perception that malingerers may be among those who attend sick call. Painting: Courtesy of US Naval Historical Center, Washington, DC.

On most ships, sick call is open two or three times each day to accommodate crew working and sleeping schedules. Patients are usually seen first by junior corpsmen; a standing operating procedure details treatment for specific problems and lists those complaints that require the attention of a physician or a senior corpsman. On large ships, many sailors gather at the clinic door for sick call and form a long line that extends down the passageway (Figure 29-3). Such lines are wasteful of the ship's manpower and demoralizing to the crew; standing in line conveys an image of inefficiency and lack of respect that undermines the crew's confidence in the Medical Department. One way to reduce waiting is to have an appointment system that allows sailors to sign up for a sick call visit the same day. An alternative is to triage the people who are waiting; those who feel acutely ill or have new injuries are brought to the front of the line, others with less-urgent problems are asked to return about 30 minutes later, and members who are there for follow-up visits are asked to return after the second group.

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 complaint where others cannot hear it, 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 by shipmates, 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 terribly important to young people who have few distractions aboard ship and can be prone to worry and ponder 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 an outbreak of physical illness. Also, of course, physical illness may cause subtle symptoms for some time before it becomes 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 grows much worse. Most important, however, the crew must fully trust the Medical Department if they are to be open and honest in giving medical histories and feel confident at times of emergency or personal crisis. While the Medical Department needs to help people return to work and discourage hypochondriasis, it is far better to tolerate "sick bay commandos" than to build a reputation for skepticism or insensitivity.

During times of busiest operational tempo, sailors are less likely to come to sick call for minor problems. At these times, members of the medical staff must walk through all work spaces to assess levels of fatigue and find people who need treatment. It is at these times that special efforts to push fluids are also necessary.

Disposition of the Sick Sailor

The MO at sea must consider proper treatment of the patient in the context of both occupational and military requirements. To determine whether a sick or injured sailor can return to duty requires understanding of his or her job and familiarity with the workspace. Often the MO needs to visit the patient's work area before deciding. Allowance must be made for the fact that work is harder and duty hours longer at sea than on shore, and that sleep deprivation and fatigue impair recovery from almost every ailment. Bed rest is the oldest and still the most reliable treatment for many ills at sea. The value of rest and repeat examination cannot be overemphasized for cases of nonspecific illness. Crewmembers 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 may exceed the berths in the Medical Department. Any sailor who must be confined to his or her own rack 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 that a sick sailor can be kept on the ship will have been established by the theater evacuation policy and the ship's own predeployment plan. Even the most sophisticated Medical Department on a ship lacks the diagnostic capability of a hospital ashore, and a smoldering illness that eludes diagnosis or a sailor who cannot return to duty can be demoralizing to the crew, deprives the ship 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.[20,21] Voice communication among Medical Departments in a battle group is the first level of consultation. 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. All of this can be done 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 with transportation on land, patients should be evacuated at sea only when predetermined medical criteria are met, opportunities for consultation and telemedicine have been fully exploited, and the risks of transport 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. Today, patient transport at sea is usually by helicopter (Figure 29-4). 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 to be arranged by higher military medical authority, 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 cannot be predicted, so all medical and personnel records must accompany the patient at the time of transfer.

Preparation is critical in cases of urgent evacuation: the patient must be stable and it must be confirmed that the receiving ship or facility is prepared to receive the patient and capable of delivering the required treatment. The definition of "stable" is elusive, but in general it means that the patient will not deteriorate hemodynamically during transport and is either breathing spontaneously or ventilated by a method that can be reliably sustained throughout the transfer. At sea as anywhere else, medical care must "first do no harm," and this includes transport. The only reason to evacuate an unstable patient is that he or she will certainly die without it.

Safety is the first consideration in preparing a

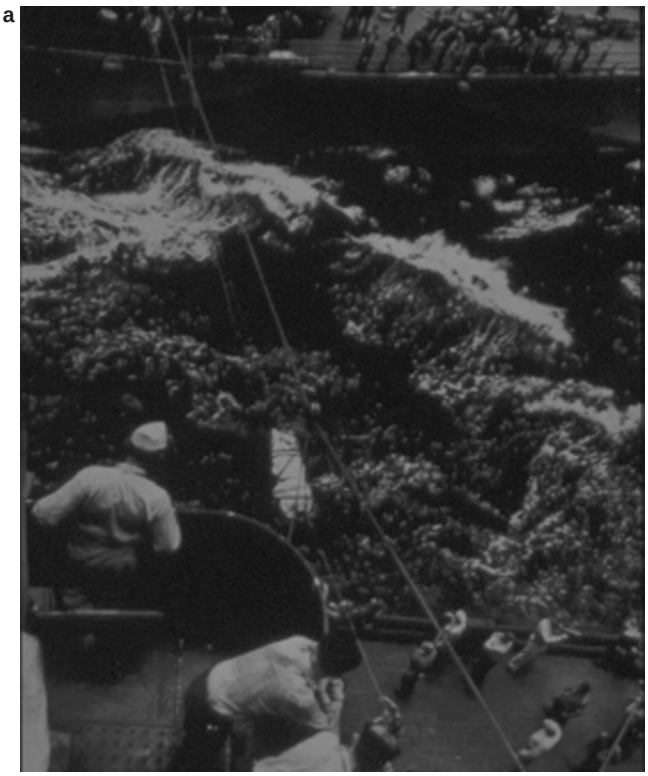

Fig. 29-4. Casualty transport at sea is a dangerous, arduous undertaking. (**a**) A casualty on a Stokes litter is being transferred from ship to ship during World War II. (**b**) A peacetime ship-to-ship transfer of a casualty using a boatswain's chair. (**c**) This peacetime casualty is being transferred from ship to helicopter on a Stokes litter because the flight deck is too small for the helicopter to land. (**d**) In this World War II mass casualty situation, a large number of casualties is being transferred back to ships by a landing craft. Photographs a and d: Official Historian, Bureau of Medicine and Surgery, Department of the Navy, Washington, DC. Photographs b and c: Navy Imaging Command, Anacostia Naval Air Station, Washington, DC. Figure legend: Courtesy of Louis Kroot, MD, Department of Emergency Medicine, University of Kentucky Chandler Medical Center, Lexington, Ky.

patient for transport. A medical escort must accompany the patient to provide care in flight. 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 with anything else on the aircraft, and intravenous fluids and blood must be contained in plastic bags without air pockets. If the patient could not survive ditching at sea, the necessity for transfer should be reconsidered.

Most patients sick enough to warrant evacuation should have supplemental oxygen, since even low-attitude 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 with 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 should have reviewed local disease surveillance reports long before the ship approaches any port of call.[7] An advance party usually visits the port to take care of diplomatic issues and arrange for docking and replenishment. It should include a medical representative, but if that is not possible, the MO must consult with the members of the advance party to assure that 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 CPOs or division officers of every department briefs their members. These briefings must include persuasive remarks about malaria prophylaxis, warnings about food- and water-borne illnesses, and safe sex practices. Unless the MO is satisfied regarding food safety and potable water supplies, the crew should be advised to avoid eating or drinking in the local economy and to take on liberty bottled water from the ship.

In areas with significant malaria risk, the MO should try to persuade the Captain either to select an alternate port for rest and recreation or to keep the crew onboard the ship. Crewmembers 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.[22] 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 crewmembers will be referred if hospitalization is 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 on shore. The MO must also explain to local providers the requirements and limitations of the ship so they will not overestimate the onboard medical facilities and return to the ship sailors who should have been treated at the hospital.

Most STDs are contracted on shore. Sexual relations among crewmembers is forbidden with mixed-gender crews but carries less social opprobrium than homosexual relations. However, experience suggests that sexual activity between shipmates occurs predominantly on shore. Educational programs that encourage abstinence, monogamous relations, and barrier (condom) protective measures are still the best ways to prevent STDs.

It is frequently suggested that the ship distribute condoms at the brow or quarterdeck as crewmembers depart on liberty, but this is not as good an idea as it first seems. All crewmembers should be provided with an appropriate and thorough educational program long before any port call. It is not the quick availability of condoms that determines whether sailors will use them but a decision in advance to practice safe sex. Modern sailors may be enlightened about sex, but many would be embarrassed to have condoms thrust upon them in public, and others are offended that someone expects them to have sex with a stranger (even though some will). Finally, both families in the United States and people in the port communities may fail to appre-

ciate the preventive medicine perspective and interpret condom distribution as encouraging casual sex. The most effective way to help sailors avoid STDs is to provide education in advance and make condoms easily available in private.

Special Medical Concerns Aboard Ship

Conditions aboard ship place many medical issues in a special context. The inclusion of increasing numbers of women in US Navy crew means that medical departments must be able to provide advice and care in areas of gynecology and obstetrics never before of concern aboard ship. The availability of highly capable, fully staffed operating rooms aboard large warships not only improves the level of care available but also obligates staffs to provide colposcopy and other services for women and also raises the question of the propriety of performing elective surgery on board instead of transferring patients to hospitals on shore. Other unusual 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 to provide obstetrical and gynecological care must be consistent with the general level of medical and surgical care on board. If the sole provider is a corpsman, he or she should be knowledgeable regarding differential diagnosis, the effects of hormonal cycles, hazards of pregnancy, 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 in the very near future pelvic and vaginal ultrasound will also be required.

From the medical planner's standpoint, the primary issues about healthcare for women are as follows:

- availability of personal hygiene items (a Supply Department issue with health implications);
- 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 have been a concern for male crewmembers, but the personal significance and medical consequences of contraception are much greater for women.

There is some evidence that women utilize medical services more often than men on land and at sea, although (with the exception of gynecological issues) the medical complaints are generally similar.[23] These results imply that as increasing numbers of women are included in naval crews, medical staffs may need to be increased and sick call lengthened to accommodate women's legitimate need for medical care. It remains to be seen whether naval women in traditionally male occupations will follow their civilian sisters in adopting high-risk lifestyles.[24]

Present US Navy policy permits women to remain assigned to sea duty for the first 20 weeks of pregnancy, *as long as the patient remains 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.[25] This 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 those first 20 weeks, a pregnant woman should be able to perform her ordinary job, although those whose work includes considerable bending and heavy lifting may need some duty limitations and may have an increased rate of musculoskeletal strain. Discovery of a pregnancy more advanced than 20 weeks requires the earliest possible gentle transfer to shore.

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 able to perform a caesarian 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 the capabilities of a large ship, 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, the propriety of performing truly elective surgery is controversial, as is any procedure while the ship is within reach of a hospital.[26] The argument against elective surgery is that even the best medical department at sea lacks the ability of a real hospital to cope with unusual complications. On the other hand, performing selected procedures maintains the skills of the surgeons, trains and exercises the surgical team, and keeps sailors on the ship where they can quickly return to duty.

The debate over elective surgery continues because both sides have strong arguments; however, a fatality during elective surgery aboard ship is intolerable. So, despite the great challenge of maintaining surgical skills aboard ship, I recommend that elective procedures be delayed until the procedure can be scheduled in a hospital on shore.

"Competence for Duty" Examinations

Sometimes a supervisor observes unusual clumsiness or poor work performance by a sailor and suspects that he or she is physically impaired because of some form of misconduct or dereliction such as consuming alcohol or drugs or staying out too late the previous night. The supervisor may then bring the sailor to the Medical Department for a formal examination to determine competence for duty. This is not a question of 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 Captain 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 crewmember is physically able to perform his or her duties and whether the crewmember is under the influence of alcohol, drugs, or other incapacitating substances, or is sleep-deprived. 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 without evidence of neurological disease, then a clinical diagnosis of intoxication can be made without a blood alcohol measurement. 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 capacity of the Medical Department to care for them, so that response requires coordination throughout the ship and rationing of 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 (Exhibit 29-2). Therefore, the highest priority is to return the greatest possible number of injured to their duties in order to keep the ship afloat and in action. All crewmembers 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.

Coordination is critical in any mass casualty situation. A senior member of the Medical Department must move immediately to Damage Control (DC) Central 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 DC 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 DC Central.

EXHIBIT 29-2

THE *FORRESTAL* FIRE

On 29 August 1967 the USS *Forrestal*, CV 59, was off the coast of Vietnam, preparing to launch attack aircraft. A Zuni rocket malfunctioned and set an A-4 Skyhawk afire on the flight deck. Within minutes several other armed aircraft caught fire, and the subsequent explosions and fuel fires set the entire flight deck ablaze (Exhibit Figure 1). Dozens of flight crew and workers on the flight deck were killed within minutes; many others were severely burned. The fires and explosions extended down many deck levels on the after half of the ship, trapping and wounding sailors in the after mess decks and in several berthing compartments.

Over the several days of the ordeal, 134 *Forrestal* sailors died and several hundred others suffered severe burns, inhalation injury, and fractures. The two after auxiliary battle dressing stations were destroyed. At the same time that firefighting was begun, a staging and triage area was set up in the forward hangar bay and forward mess decks. All flight operations were impossible, so evacuation was delayed for several days. The first casualties arrived in the main medical area within 10 minutes, and the operating room was in constant use for several days. Major treatment areas had to be set up in the forward battle dressing stations on the O-3 deck just below the flight deck and in the forward mess decks. The 53 beds in the medical ward were quickly filled, so patients were treated in makeshift holding beds in mess decks—and some commandeered berthing compartments.

As tragic as the loss of life was in this fire, the rapid action of the Medical Department was responsible for saving the lives of dozens of patients. By returning most of the casualties to duty to fight the fires and control damage, the Medical Department also indirectly helped save the lives of others on the ship.

Exhibit Figure 1. (a) On 29 August 1967, armed US Navy aircraft exploded and burned as they sat on the flight deck of the USS *Forrestal*; crews attempted to extinguish the fires while the aircraft burned, but the explosions and ensuing conflagration claimed the lives of 134 sailors. **(b)** The exploding bombs detonated by the fires blew holes through the flight deck of the *Forrestal*. In an attempt to cool parts of the wreckage below in the hangar deck, crews cut holes through the flight deck and hosed water down to the wreckage below. **(c)** Cleanup proceeded in the aftermath of the fire. The ghostlike structure at the top of the photograph is the mast of another ship astern of the USS *Forrestal*. Photographs: Navy Imaging Command, Anacostia Naval Air Station, Washington, DC. Figure legend: Courtesy of Louis Kroot, MD, Department of Emergency Medicine, University of Kentucky Chandler Medical Center, Lexington, Ky.

Corpses

The unpleasant but necessary topic of disposition of human remains aboard ship is frequently misunderstood and can cause confusion and discord at very difficult times. The XO and all department heads must understand before the ship leaves the pier that the Medical Department does not take care of corpses. The fact that death certificates, medical records, and autopsies are handled by medical specialists can be misleading. In operational and doctrinal terms, however, a human body ceases to be a person at the time of death and can no longer be a patient. *Management and transport of corpses is NOT the job of the Medical Department.* Procurement and storage of materiel such as coffins, transport boxes, or body bags are the responsibility of the Supply Department.

Death at sea is difficult for a crew regardless of the circumstances. Soon after a death occurs is not a good time to discuss with the XO or Captain the best way to handle human remains, so they must understand the issue beforehand. When the XO asks the MO about topics such as the inventory of coffins or refrigerators for corpses, the MO must quickly and persuasively redirect the questions to the Supply Officer.

The Walking 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. Dried frozen blood and synthetic oxygen-carrying fluids may soon provide blood replacement at sea, but as of this writing, severe blood loss at sea can only be treated by using blood from shipmates. The term "walking blood bank" refers to a group of prescreened, registered volunteers with known blood types who are prepared to donate blood for emergency transfusions at sea. Such blood does not meet the standards of the safe blood supply found in modern medical centers. For example, there is always a risk that a donor has acquired a pathogen such as the human immunodeficiency virus (HIV) between the last set of tests and donation; such a risk is unacceptable in ordinary medical circumstances. Critics of the walking blood bank argue that planning for the use of blood in this manner constitutes an endorsement of substandard practice. On the other hand, the walking blood bank is a source of vital oxygen-carrying fluid when blood replacement is absolutely necessary to preserve life and limb.

The roster of the potential donors should begin with volunteers, but it is understood that all crewmembers expected to participate if necessary. All members of the crew must have a known, confirmed record of blood type and receive annual screening tests for syphilis and HIV as well as tuberculosis skin tests. Additional screening of volunteers for the blood bank is time-consuming; it must be done before going to sea and repeated at least annually. Medical history should exclude members who have ever had malaria, leishmaniasis, or any other blood-borne disease. Laboratory procedures should include examination of a blood smear, a hepatitis panel, and tests to screen out blood dyscrasias and hemoglobin variants such as sickle cell trait, thalassemia minor, or glucose-6-phosphate dehydrogenase deficiency. Use of the walking blood bank must be rehearsed during workups and periodically during the cruise to ensure that all donors and their supervisors are familiar with the procedures.

Disposal of Medical Waste

In the past, ships disposed of all trash and refuse at sea, but times have changed. Now, only that which is biologically degradable and harmless to ocean ecology and the sea floor is thrown over the side. No plastic is disposed of at sea and great efforts are made to limit the amount of plastic that is even allowed aboard. Ships are now very concerned with how to limit the amount of, and how to handle, the seven classes of waste:

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 to be eagerly and safely devoured;
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

Few undertakings in the medical profession are as challenging or as rewarding as running a Medical Department at sea. Anyone who has done so remembers it as the high point of a career. Nowhere do the patients and the entire community depend more on the skills and compassion of the healers. The demands of life at sea, the very environment of the ship, define medical care just as much as do the basic principles of medicine. Only by thoroughly integrating the Medical Department with the crew, by careful and continuous planning, and by adapting to the ship's cycle can the MO give the crew and the ship the best possible medical care.

The organization of the ship, its physical structure, and its specific mission form the working environment for the crew and the Medical Department. Life on board is constrained by limited space for work and tight living quarters with very little privacy. The kind of work and the tempo vary markedly with the ship's cycle, consisting of workups and training; deployment; maintenance periods in the yards; and major overhauls, which take the ship out of service for many months.

The Medical Department aboard ship is configured and staffed to meet the needs of the specific ship and its mission, and it ranges from a single corpsman on a small ship to a staff of about 70, including staff for the operating room aboard an aircraft carrier or large amphibious landing ship. The MO is unique in serving both line and staff roles. The line function consists of running the Medical Department on a daily basis; the staff role requires that the MO provide sage advice to the Captain and the XO concerning medical aspects of military planning and the overall health and morale of the crew, an important aspect of the ship's readiness for action.

Medical care aboard ship is expected to meet the standards of a community hospital of comparable size on shore, reflecting the widespread public misperceptions about medical capabilities during combat; provider credentials and privileges are closely monitored, and the adequacy of the Medical Department and its preparation for emergencies are frequently inspected by higher medical authority within the Navy. The medical staff is also responsible for training the crew with respect to first aid, mass casualty response, and personal health issues.

Predeployment planning is the bedrock of medical preparedness for a cruise. Everything the ship will need for the entire deployment must be on board when the ship leaves the pier. Planning includes obtaining up-to-date medical intelligence regarding health risks in the area of the cruise and especially in ports of call. The MOs of ships that will travel in company should get to know each other and are required to define the medical capabilities of each ship and its staff, to allow planning for consultation and appropriate transfer of patients whose clinical condition is beyond the capabilities of the ship. Detailed plans for medical evacuation must be coordinated with fleet operations. And the crew must be screened for acute and chronic medical conditions, some of which may be disqualifying, and receive necessary immunizations before departure.

The shipboard environment changes in many ways with the ship's cycle. A ship in the yard has on board not only its crew but also numerous civilian workers. Activities of heavy industry prevail, with heat, noise, grinding, and welding throughout the ship. The Medical Department shares with the Engineering and Safety officers the responsibility for preventing injuries. When the ship is at sea, the pressure of work and long hours prevail; confinement in crowded spaces together with a paradoxical loneliness often precipitate psychological crises, especially among young crewmembers leaving home for the first time. Outbreaks of food-borne illness, respiratory disease, and skin conditions are common problems that require immediate action by the medical staff. Constant vigilance and careful hygiene in heads and galleys are required to control cockroaches and rodents. Closed spaces aboard ship readily become hypoxic and pose a serious risk to the unwary, especially during periods in the yard. The Medical Department must always be on alert during flight operations because of multiple hazards, including the risk of aircraft crashing into the sea and jet blast blowing a deckhand overboard.

Medical care at sea is based on daily sick call, which provides routine care for physical ills and a haven for stressed sailors. It is also a tool for monitoring the overall health and well-being of the crew. Sick sailors may be recommended for light duty or bed rest, or they may be admitted to sick bay. Anyone who remains ill beyond a predetermined time limit must be transferred to a more-capable medical facility. Telemedicine should be readily used for consultation to improve medical care and to prevent unnecessary medical evacuation. Only stable patients can be transferred except in life-threatening situations, and the receiving facility must always be warned in advance of the incoming patient. The smoothest transfer of a patient is made at the pier; most transport at sea is by helicopter and re-

quires special preparation of the patient for flight. Port calls require medical planning to provide appropriate health advice to crewmembers and coordinate medical care with authorities ashore.

Shipboard medicine includes a number of special concerns. Inclusion of women in crews requires provision of basic gynecological care and the capability to deliver a baby if required. Large ships have true operating rooms and carry surgical staffs; performance of elective procedures on board is sometimes advocated as a means of maintaining staff competence, but this is inadvisable because the limited facilities on a ship cannot deal with rare but potentially fatal complications. The medical staff may be asked to perform "Competence for Duty" examinations and needs to understand the legal ramifications of this task. The Medical Department is a key element in planning and drills for mass casualty situations, including triage, patient transportation, and emergency communication in a heavily damaged ship. Other issues include the disposition of corpses (not a medical responsibility), the organization of a walking blood bank, and the disposal of medical waste.

ACKNOWLEDGMENT

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Chapter 29: ATTACHMENT

SHIPBOARD MEDICINE DURING WAR

Prepared for this textbook by Louis Kroot, MD, Commander, Medical Corps, US Navy (Ret), Surface Warfare Medical Department Officer; currently, Department of Emergency Medicine, University of Kentucky Chandler Medical School, Lexington, Kentucky 40536-0298.

Unlike ground combat, there are no echelons of medical care during naval warfare within a given ship. Medical care in ground combat begins with immediate basic care given at squad level. Should the injured require more definitive care, they are transported to next level of care. In naval warfare, medical care is limited initially to what is aboard the ship. Unlike an army division, a ship cannot detach a portion of its medical assets while the remainder of the division continues on with its primary mission. If the decision is made that one ship has to assist another, its entire primary mission must be subordinated to transporting its medical assets to assist another vessel that is already unable to meet its mission requirements. Assisting a disabled vessel during wartim*e effectively doubles* the number of vessels unavailable to the operational commander.

Battle Damage to Surface Ships

As Captain Richard R. Cooper wrote in his article, "Medical Support to the Fleet"[1]:

> Medical support during battle at sea cannot be implemented effectively unless the scenario includes 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 upon supporting those who are able to fight the ship.
> - Transfer to another unit is feasible despite the isolation of the ship, bad weather or an ongoing battle.
> - The receiving unit has its own medical capabilities, a place to hold the wounded and the ability either to treat the patient or to transfer him out of the battle force.

The delivery of medical care during battle is completely different from that of peacetime naval medical practice because *saving the ship has 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 the immediate effects of the weapons causing the damage. During General Quarters (the condition when a ship is ready to go into battle), ships compartments and air shafts are sealed to control fire and flooding. All movement is coordinated and cleared through Damage Control Central to ensure that air and watertight integrity are maintained, thus minimizing and controlling damage from enemy missiles, torpedoes, shells, and mines. When the ship is damaged by enemy action or accidents, repair parties (which are preassigned and trained) for specific areas of the ship will respond to control the threat. The threat of fire and flooding are so great that if casualties are in a space that is damaged, the repair party will only move them out of their way in order to control the damage. *Only when the threat is contained will the injured be removed for medical assistance.*

Other important factors differentiate shipboard battle casualties from ground casualties, namely, the circumstances of wounding (how they occur) and the nature of the wounds. Unlike ground combat, in which the occurrence of casualties is usually continuous, shipboard casualties are generated suddenly and in large numbers. Naval history abounds in examples of what happens to the crew when a warship sustains sudden catastrophic damage. For example, after a magazine explosion broke HMS *Hood* into two parts that sank within 3 minutes, only 3 survived of a crew of 1,400.[2]

More-manageable examples of battle damage and the associated casualties are found in the following examples. In March 1945, the flight deck of the USS *Franklin* 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 down to but not including the ship's machinery, killing 724 and wounding 264 of the ship's crew (Attachment Figure 1). The main battle dressing station

(BDS) was destroyed and all the ship's doctors but one were trapped below deck for hours.[3] The experience of the one doctor who was able to care for the wounded aboard the *Franklin*—Samuel Robert Sherman, Medical Corps, US Naval Reserve—is well worth reading for its graphic description of the realities of shipboard medicine during war.[3]

During the Okinawa campaign in World War II, the USS *Princeton* took a kamikaze hit that caused 292 casualties: 9 killed in action (KIA), 191 wounded in action (WIA), and 92 missing. The USS *Birmingham* came to assist the *Princeton*. When the *Princeton* exploded, she caused 50% of the *Birmingham*'s crew to be killed or wounded. The *Birmingham's* Medical Department, which consisted of 1 medical officer and 14 corpsmen, provided care for 420 wounded men from both ships. Only 8 of the wounded died (DOW). Five had to be operated on and of those, two died.[4]

The USS *New Mexico* also took a kamikaze hit, resulting in 30 KIA and 129 WIA. The tactical situation prevented the evacuation for nearly 2 weeks. The severely injured were forced to wait until night for definitive treatment. These extreme circumstances caused great anxiety among the injured as well as adversely affecting the morale of the crew; according to the Senior Medical Officer aboard the USS *New Mexico*,

> Too much emphasis cannot be placed upon the importance of early evacuation of the wounded from a damaged ship.[4]

A listing of more-recent combatlike incidents aboard US Navy vessels and the associated casualties is found in Attachment Table 1.

US Navy data on casualty generation have been extensively studied; interested readers can consult C. G. Blood's seminal work on the subject, *Analysis of Battle Casualties by Weapon Type Aboard US Navy Warships*.[5] Although Blood's analysis is based on World War II data (that is to say, damage to ships of World War II design by World War II–era weapons), the results—with qualifications such as the disappearance of heavily armored and protected ships and the replacement of large-caliber guns by guided missiles—remain applicable to the present. The most common weapons that struck American warships in World War II were as follows[5]:

1. kamikaze-piloted planes, 37%
2. gunfire, 23%
3. bombs, 16%
4. torpedoes, 14%
5. multiple kinds of weapons, 6%, and
6. mines, 4%.

Attachment Fig. 1. (**a**) This famous photograph was taken from aboard the USS *Santa Fe* as that cruiser came alongside the damaged USS *Franklin* several hours after the successful Japanese bombing attack. The entire aft portion of the ship above the machinery space is engulfed by fire. The list to starboard resulted not from damage to the hull but from the accumulated weight of water used to fight the fires. (**b**) Billowing smoke nearly obscures the *Franklin* in this photograph, which was taken about the same time from a low-flying airplane. Some of the *Franklin's* surviving crew, seen in both views, await rescue by the *Santa Fe*. The damage incurred by the *Franklin* was of the same magnitude as that sustained by the four Japanese aircraft carriers that were sunk in the Battle of Midway. Photographs: Courtesy of US Navy.

ATTACHMENT TABLE 1

SELECTED SHIP DISASTERS AND CASUALTIES AT SEA

Ship	Date	Type of Disaster and Casualty Information
USS *Franklin*[1]	1945	1,000 casualties: 800 died, 210 from burns, 133 from asphyxiation
USS *Oriskany*[2]	1966	Fire and explosion on the hangar deck; 44 dead, 24 from smoke inhalation
IDF destroyer *Eliat*[3]	1967	Hit and sunk by a cruise missile. A second missile exploded in the water. Of the casualties, 32 sailors who were in the water at the time were rescued and transferred to a hospital in Cyprus within 5–6 h; 24 developed signs of abdominal injury; 23 had tears in the viscera or bleeding intestines; 4 died postoperatively; and 19 had significant lung injury.
USS *Forrestal*[2,4]	1968	Fire and explosion on the flight deck; 134 dead, 168 injured
USS *Enterprise*[5]	1969	Fire on the flight deck; 27 dead, 85 injured
USS *Belknap*/USS *Kennedy*[6]	1975	Collision; on the *Belknap*, 8 dead, 45 injured; on the *Kennedy*, 1 dead, 2 injured
Sir Galahad Auxiliary[4]	1982	Sunk during Falkland War; 179 casualties, 83 with burns
HMS *Sheffield*[4]	1982	Heat from an *unexploded* Exocet cruise missile caused fire in 15–20 sec; 20 dead, 24 with burns and smoke inhalation
USS *Stark*[1,6]	1984	Hit by two Exocet cruise missiles; total dead = 37, total injured = 15. Two of the injured had 23% and 42% TBSA burns. Of the 37 fatalities, 17 had blast injuries, 13 had burn injuries, 3 had blast/burn injuries, 2 had smoke inhalation, 1 had asphyxia, and 1 body was never recovered.
USS *Bonefish*[7]	1988	Fire; 22 injured from burns and smoke, 3 died of smoke inhalation

IDF: Israeli Defence Forces; TBSA: total body surface area

Sources for casualty data: (1) Pinkstaff CA, Sturtz DL, Bellamy RF. USS *Franklin* and the USS *Stark*: Recurrent problems in the prevention and treatment of naval battle casualties. *Mil Med*. 1989;154(5):229–233. (2) Foster WF. Fire on the hangar deck: *Oriskany*'s tragedy, October 1966. *The Hook*. 1988;Winter:38–53. (3) Smith AM. Getting them out alive. *Naval Proceedings*. 1989;Feb:41–46. (4) Smith AM. Any navy can go to war alone, but staying there is another thing. *Navy Medicine*. 1990;Nov-Dec;9–15. (5) Bellamy RF. Colonel, Medical Corps, US Army (Ret). Personal experience, January 1969. (6) Smith AM. Lecture at Uniformed Services University of the Health Sciences on the USS *Belknap*/USS *Kennedy* collision and USS *Bonefish* casualties. Bethesda, Md; 1991. (7) Hooper RR. Medical support for the fleet. *Naval War College Review*. 1990; Summer:43–54.

During World War II, the KIA to WIA ratio aboard a ship was 1:1, except when the weapon was torpedoes or torpedoes with multiple weapons, when the ratio was 2:1 (in ground forces, the KIA:WIA ratio is 1:4).[6] Cruisers had the largest absolute number of casualties, followed by carriers and then by escort carriers. The average number of casualties on any ship hit was 38 KIA and 34 WIA. Casualties surviving to be treated included 39% with penetrating wounds; 21% burns; 11% with both burns and penetrating wounds. No other significant grouping of types of wounds was seen, although crewmen of torpedoed or mined ships may sustain extremity fractures that are caused by rapid translation motion of the deck due to blast. Kamikaze attacks generated 37% penetrating wounds, 30% burns, 9% multiple wounds.[5] Medical officers need to understand that kamikaze attacks have considerable relevance to modern naval warfare because of their similarity to today's guided antiship missiles (kamikaze attacks can be thought of as roughly equivalent to modern Cruise missiles [ie, the organic guidance systems—the human pilots—were replaced by silicon guidance systems—computers]). Thus, blast and burn with associated inhalation injuries can be expected to be more common than in the past.

In order not to lose all medical assets in a single hit, the Medical Department mans BDSs throughout the ship, in addition to the main medical spaces (see Figure 29-2 in Chapter 29, Shipboard Medicine). It has also been recognized that trying to move medical supplies and litters to the injured from the sickbay and assuming that power will not be interrupted during combat are unrealistic. Therefore, scattered throughout the ship are first aid boxes; portable medical lockers (PMLs; also called a BDS in a box); decontamination boxes; and litters, their numbers being prescribed by Navy regulations (Attachment Exhibit 1). Each BDS is equipped with a 50-gal gravity-fed water tank; multiple battery-powered lanterns, which are being recharged while there is power; and is on the emergency backup power system and has emergency 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. One key factor that optimizes shipboard medicine during war that is directly dependent on the ship's medical officers is crew training (Attachment Exhibit 2).

Sinking, Immersion, and Survival

Despite the horrific nature of immediate, direct damage inflicted on ships in naval warfare, the experience of both the Royal Navy[7] and the US Navy[8] has been that 66% of deaths occurred *after* the crew had successfully abandoned a sinking ship. Unless a sinking occurs in tropical waters, the main threat to a sailor's survival is the environment. The most critical items for survival after sinking are extra clothing and blankets. The critical need for water and food occurs in days for water (the record is 11 days without water) and weeks for food. The hazards associated with immersion are listed in Attachment Exhibit 3. Water conducts heat 25-fold faster than air; the problem with sudden exposure to cold is induced sympathetic reflex, which causes tachycardia, hypertension, tetany, and hyperventilation. In choppy water, this can lead to drowning. Death occurs from drowning before death from hypothermia because the hypothermic, lethargic sailor loses the ability to protect his airway and turn his back to a choppy sea. A sailor's survival after abandoning a ship is dependent on the water temperature, sea state, swimming ability, physical conditioning, and acclimatization to the cold. According to Royal Navy data, many deaths from hypothermia occurred within the first 24 hours after immersion, even in the English Channel. But if a sailor survived the first 24 hours of immersion, his chances for survival improved dramatically.[7]

The next greatest time of risk for the survivors after a ship sinks occurs shortly after they are rescued from the water. During World War II and continuing to the present, the syndrome of sudden collapse and death after the rescue has 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 life raft survivors were rescued; of these, 69 had hypothermia and 18 died of exposure; about 600 men had already been killed when the ship sank. After the British *Atlantic Conveyer* sank, 12 of her crew, most of whom were in the water, died; 2 sailors drowned after the HMS *Coventry* was sunk.[9] Both the Royal Navy and the US Navy have made recommendations for maximizing the survival of sailors who have suffered from immersion (Attachment Exhibit 4).

After the environment, the next greatest threat to survival at sea is lack of potable water. The Royal Navy has found that 150 mL of water per day was associated with a 22% mortality for a 6-day period. However, when water consumption was between 150 and 450 mL/day, the mortality was 0.6% for the same period.[7] Their recommendation is that no water be drunk the first day except by the injured, and that the water be given three times a day in a measured beaker. In the tropics the Royal Navy recommends that work be done *only* during the cool of the day. Soaking clothing in sea water can decrease sweating by 83%,[7] but the clothing must be allowed to dry before sunset to avoid heat loss at night.

The concentration of body fluids is 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 concentration of salt 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 of these scenarios hasten death.[7] *An absolute prohibition is needed against drinking seawater or mixing it with freshwater.* The mortality of survivors of a sinking who did and did not drink seawater is given in Attachment Table 2.

ATTACHMENT EXHIBIT 1

SHIPBOARD REQUIREMENTS FOR SPECIFIC MEDICAL EQUIPMENT

Medical Equipment per 100 Personnel	No. of Personnel
1. First Aid Boxes	
4	< 500
5/100	500
8/100	1,500–3,000
10/100	> 3,000
2. Stokes Litters	
1.5/100	< 1,500
3/100	1,500–3,000
4.5/100	> 3,000

3. Neil Robertson Litters: 1 located adjacent to each vertical trunk, machine room, and shop space

4. Portable Medical Lockers (PMLs): located adjacent to each repair party station; 1 PML per 250 personnel

5. Battle Dressing Stations: number determined by class of ship; minimum: 2 (frigates) to 6 (aircraft carriers); (see Figure 29-2 in Chapter 29, Shipboard Medicine)

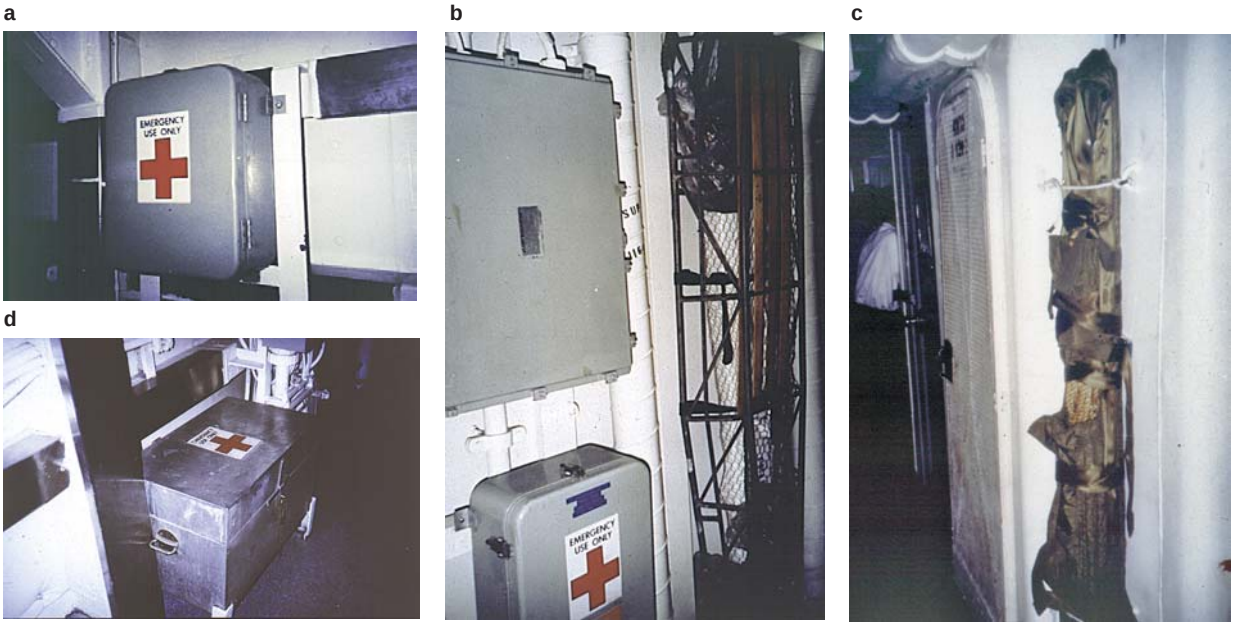

Exhibit Fig. 1. (**a**) A first aid box; these are located throughout the ship. (**b**) The Stokes litter and (**c**) the Neil Robertson litter are especially useful onboard ships, because once a casuality is securely fastened on the litter and the wire cage is in place (Stokes litter), he can be transported in any direction (eg, from ship to ship or up and down vertical ladders to the battle stations). (**d**) A portable medical locker, which is sometimes called a "battle dressing station in a box." Exhibit text adapted from US Navy. *Shipboard Medical Procedure Manual*. Washington, DC: US Navy. COMNAVSURFLANT/PAC Instruction 6000.1. Photographs: Naval Imaging Command, Anacostia Naval Air Station, Washington, DC.

ATTACHMENT EXHIBIT 2

CREW TRAINING IN PREPARATION FOR BATTLE

Crewmembers to be trained:

- Corpsmen
- Litter bearers

Training tools and techniques:

- Closed-circuit television (CCTV) lectures
- Navy training films
- First aid (self and buddy aid)
- American Heart Association's Basic Life Support course

Training content in preparation for battle:

- Battle bill
- Battle dressing stations
- Repair parties
- Portable medical lockers
- Decontamination lockers
- First aid boxes
- "Gun" bags

Amphibious Operations

Amphibious operations against a defended beachhead are the most arduous and dangerous type of military campaign. On the first day of amphibious assault at Tarawa, Saipan, Peleliu, and Iwo Jima, the WIA rate per 1,000 men was, respectively, 55, 75, 63, and 60.[8] The reason there are so many medical assets and spaces aboard amphibious ships is that, in reality, two separate crews are assigned, Navy and Marine. The problem of caring for casualties aboard ships was summed up best in the *History of The Medical Department of The United States Navy in World War II*:

> It was part of a pattern of thought which permeated the forces afloat and influenced the establishment of hospital facilities ashore. It was the "bed for a casualty" type of thinking; in other words as long as the wounded man was in a bunk and out of sight of the troops, part of the medical mission was accomplished. It must be recognized that war wounds are surgical problems, best handled by a trained surgeon during the golden hours of early surgery. When one considers the facilities and personnel required to care for 150 seriously wounded patients, as well as for 325 patients with minor wounds, it becomes apparent that *three medical officers with limited equipment, regardless of their talent or heroic efforts, will not suffice.*[4]

Naval and Marine leaders are well aware of the difficulties in amphibious operations. There are accepted manuals and protocols for effective command, communication, control, and logistical support for formal amphibious operations. With time for adequate planning, practice, and support, medical resources can be integrated effectively into amphibious operations and mistakes of the past avoided.[4]

From the invasion of Tarawa, where all the casualties on litters were placed aboard a single amphibious tractor that was sunk before it reached the beach, we learned not to concentrate medical resources in one location. In the invasion of Saipan, without medical advice, casualties were evacuated in aircraft by line officers. The aircraft arrived at its destination with casualties who had died of their wounds or were in poor condition. In the subsequent invasion of Iwo Jima, before an airhead had been established, casualties were placed on a landing craft for transport to a ship.

ATTACHMENT EXHIBIT 3

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.

ATTACHMENT EXHIBIT 4

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

[*]There is currently no other accepted therapy for treating hypothermia.

[†]During World War II, many sailors were lost when they attempted to climb the net up the side of the rescuing vessel. The effort was too great; they fell back into the sea and were lost. During the latter stages of the Battle of the Atlantic, lifeboats were lowered and sailors pulled into them; they were then hoisted aboard ships. Also, special ships at the end of convoys were outfitted with large booms with netting; these were swung out to sea for sailors to grab onto. The booms were swung back in and the sailors lifted to safety.

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

Some casualties were aboard the landing craft for up to 8 hours without medical attendants or supplies. Later, after airfields had been established, 2,500 casualties received medical clearance before being evacuated by air from Iwo Jima. The medical clearance process decided which casualties were stable enough for transport; this resulted in no deaths during this air evacuation.[4] As these examples demonstrate, casualties are not static problems, like broken equipment; the physical conditions of casualties will generally deteriorate over time if no medical intervention occurs.

Today's Navy does not have the quantity of dedicated medical resources to support amphibious operations that were available at the end of World War II and the Korean War. Additionally, with the improvement in satellite communication and surveillance, the time to recognize and respond to a threat has decreased dramatically, and the distance at which the US military can successfully intervene has correspondingly

ATTACHMENT TABLE 2

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 Defence, Medical Directorate General (Naval); July 1981. BR 2193.

increased. The need for operational security, the tension between the operational plan and the logistical support, and the priority to deploy combat power quickly have resulted in amphibious operations suddenly commencing with only peacetime medical resources available to support the operational commitments. For example, during Operation Urgent Fury (the 1983 invasion of Grenada), the USS *Guam* received 37 casualties. There had been no prior triage before the casualties were sent to the ship. Twenty-three cases of lactated Ringer's solution were used in 1 day, and the inventory had to be replaced three times from other ships. The 50 units of blood in the blood bank were inadequate and had to be resupplied—initially from the walking blood bank of the *Guam*'s crew. The blood bank was later supplemented from the USS *Independence*'s walking blood bank. According to the Medical Officer of the USS *Guam*,

> at one point I got so desperate [from the volume and rate of casualty arrival that] I merely matched blood type from the patient's dog tag and drew from one [the crewmember of the USS Guam] and transfused to another [the casualty].[9]

The capability of launching amphibious operations from "over the horizon," which involve both landing craft and aircraft, brings new vulnerabilities. The accelerated pace and depth of which today's military is capable have created increased demands on medical support to sustain military operations and to care for casualties from both military and civilian victims of a conflict.

SUMMARY

Shipboard medicine during war differs from combat casualty care on land because of the following characteristics: the occurrence of sudden and potentially catastrophic damage to the ship; the grave risk that the ship will sink; a mass casualty situation dominated by thermal, blast, and inhalation injuries; and, frequently, the destruction of the medical treatment facilities. And when ships sink, the risk to the surviving crew is not over. Death from drowning, hypothermia, and dehydration are common occurrences. It is no exaggeration to say that shipboard medicine during war provides the greatest challenge likely to be faced by the military physician.

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