Maritime Applications of Prolonged Casualty Care

Sepsis on a Destroyer During Distributed Maritime Operations

Matthew D. Tadlock, MD[1]; Ryan C. Maves, MD[2]; Dana M. Flieger, MSN[3]; Tyler J. Baldino, DO[4]; Donald Adams, PhD, MPAS, PA-C[5]; Jamie C. Riesberg, MD[6]; Levi K. Kitchen, MD[7]; Jermy J. Brower[8]; Michael S. Tripp, MD[9]*

ABSTRACT

During distributed maritime operations, individual components of the naval force are more geographically dispersed. As the U.S. Navy further develops this concept, smaller vessels may be operating at a significant time and distance away from more advanced medical capabilities. Therefore, during both current and future contested Distributed Maritime Operations, Role 1 maritime caregivers such as Independent Duty Corpsman will have to manage patients for prolonged periods of time. This manuscript presents an innovative approach to teaching complex operational medicine concepts (including Prolonged Casualty Care [PCC]) to austere Role 1 maritime caregivers using a hypothetical scenario involving a patient with sepsis and septic shock. The scenario incorporates the Joint Trauma System PCC Clinical Practice Guidelines (CPG) and other standard references. The scenario includes a stem clinical vignette, expected clinical changes for the affected patient at specific time points (e.g., time 0, 1, 2, and 48h), and expected interventions based on the PCC CPG and available shipboard equipment. Epidemiology of sepsis in the deployed environment is also reviewed. This process also identifies opportunities to improve training, clinical skills sustainment, and standard shipboard medical supplies.

KEYWORDS: *prolonged casualty care; tactical combat casualty care; maritime operations; critical care; sepsis; septic shock; appendicitis*

Introduction

Current United States (U.S.) Navy and North Atlantic Treaty Organization (NATO) maritime strategy is coalescing around the concept of Distributed Maritime Operations to prepare for future multidomain and large-scale combat operations (LSCO) with peer competitors. In contrast to previous doctrine, where naval forces deploy within a strike group, individual components of the naval force are more geographically dispersed during Distributed Maritime Operations, operating at a significant time and distance from each other and form higher levels of medical care. This is the first in a series of teaching scenarios demonstrating the practical application of the Joint Trauma System (JTS) Prolonged Casualty Care (PCC) Clinical Practice Guidelines (CPG) in the deployed maritime environment to help prepare shipboard Independent Duty Corpsmen (IDC) and other Role 1 maritime caregivers to provide complex medical care in the distributed maritime environment.[1] The PCC CPG introduction emphasizes key principles that "make the care of a critically ill patient more efficient" for Role 1 caregivers in any austere environment. These include first following the Committee on Tactical Combat Casualty Care (CoTCCC) guidelines,[2] performing a comprehensive physical exam and detailed history with a problem list and care plan, recording and trending vital signs, creating a nursing care plan, obtaining and interpreting lab studies, performing necessary surgical procedures, and preparing for transportation or medical evacuation (MEDEVAC). The PCC CPG also describes periodic mini-rounds to assess patient stability and recognition of a patient who is "sick or not sick."[3]

Sepsis was chosen first because its management involves core clinical competencies required for effective PCC. The Surviving Sepsis Guidelines (first published in 2004) include many key evidence-based critical care competencies foundational to

*Correspondence to Matthew D. Tadlock, MD, Department of Surgery, Navy Medical Readiness and Training Center, San Diego, 34800 Bob Wilson Dr., San Diego, CA 92134 *or* matthewtadlockmd@gmail.com

[1]**CAPT Matthew D. Tadlock** is the Simulation Fellowship Director and Trauma/Critical Care Surgeon at the Naval Medicine Readiness and Training Command, San Diego, CA. [2]**CAPT (R) Ryan C. Maves** is an Infectious Disease and Critical Care Physician at the Sections of Infectious Diseases and Critical Care Medicine, Wake Forest University School of Medicine, Winston-Salem, NC. [3]**LCDR Dana M. Flieger** is a critical care nurse at the Naval Medicine Readiness and Training Command, Camp Lejeune, NC. [4]**LT Tyler J. Baldino** is a Resident Physician at the Department of Emergency Medicine, Naval Medicine Readiness and Training Command, Portsmouth, VA. [5]**Dr. Donald Adams** is an Adjunct Assistant Professor of Clinical Research and Leadership at the George Washington University School of Medicine and Health Sciences, Washington, DC. [6]**COL (R) Jamie C. Riesberg** is the Director of Military Medicine at Montana College of Osteopathic Medicine, Billings, MT. [7]**CDR Levi K. Kitchen** is an emergency medicine physician in the Department of Emergency Medicine and Director, Healthcare Simulation and Bioskills Training Center at Naval Medicine Readiness and Training Command, Portsmouth, VA. [8]**HMCM Jermy J. Brower** is an Independent Duty Corpsman at U.S. 3rd Fleet, San Diego, CA. [9]**CAPT (R) Michael S. Tripp** is a critical care physician at the Chest Medicine and Critical Care Medical Group, San Diego, CA.

PCC: recognizing critical illness, resuscitation and hemodynamic support, respiratory support, and complication prevention and management.[4–6] Therefore, learning the management principles of sepsis and septic shock provides an introduction to core critical care competencies and, by proxy, the principles described in the PCC CPG. Sepsis was also chosen because infected war wounds have plagued combat casualties as long as there has been war.[7] In the Vietnam War, sepsis was the third leading cause of death (11.7%) of in-theater hospitalized combat casualties, behind head injury (42.5%) and hemorrhagic shock (23.9%).[8] It is likely that in any future conflict involving an LSCO, casualties with contaminated and infected war wounds will require PCC at or near the point of injury. Aeromedical opportunities are also likely to be limited as the U.S. and Allied Forces are unlikely to have the air superiority experienced during the last 20+ years of war. In this potential future operating environment, combat casualties with contaminated war wounds will require care at or near the point of injury for hours to days before MEDEVAC to a higher level of care is possible. Therefore, far-forward Role 1 caregivers in any austere environment must understand the principles of infection prevention and sepsis management.

Epidemiology

Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection. Septic shock is a subset of sepsis in which underlying circulatory and cellular metabolism abnormalities are profound enough to substantially increase mortality.[9] Clinically, septic shock manifests as persistent hypotension requiring vasopressors to maintain a mean arterial pressure (MAP) >65mmHg and serum lactate >2mmol/L despite adequate volume resuscitation.[10] Any infection can evolve into life-threatening sepsis or septic shock, including but not limited to skin and soft tissue infections (SSTI) such as cellulitis, abscesses, and necrotizing soft tissue infections. Other common causes of sepsis include gastrointestinal perforations (e.g., appendicitis and diverticulitis), perirectal abscesses, urinary tract infections (e.g., pyelonephritis), pneumonia, gynecologic infections, and biliary diseases (e.g., cholecystitis and cholangitis). The most common diagnoses associated with sepsis hospitalizations in active-duty service members are pneumonia, pyelonephritis, urinary tract infections, post-operative infections, and cellulitis of the lower extremities. From 2011 through 2020, women had a nearly twofold higher incidence of sepsis hospitalizations than men and were more likely to have urinary tract infections and pyelonephritis; men were more likely to have cellulitis.[11]

Maritime PCC Scenario

The following text is a clinical scenario addressed to the Independent Duty Corpsman or other medical professionals for training purposes. It is designed for training and to highlight Role 1 shipboard medical department capabilities and limitations.

Setting

A U.S. Navy Arleigh Burke-class guided-missile destroyer (DDG) with a crew of 314 Sailors is conducting solo freedom of navigation operations in the Indo-Pacific Command (INDOPACOM) Area of Responsibility. Based on the current mission and location, any patient would need to wait 72–96h before MEDEVAC to a higher level of care with critical care or surgical capability is possible. The medical personnel and capability include one Independent Duty Corpsman and two junior Corpsmen, two stacked ward beds, and basic point-of-care labs. Available laboratory capabilities include a rapid complete blood count (CBC, utilizing QBC® STAR™ (Drucker Diagnostics, Port Maltida, PA, USA; https://druckerdiagnostics.com), dipstick urinalysis (UA), finger stick glucose with a glucometer, and fecal occult blood testing.[12] There is no ultrasound, cardiac monitoring, electrocardiogram, or x-ray capability.

Patient

A 20-year-old male Sailor presents to DDG Main Medical with approximately 12 days of abdominal pain. The Sailor is new to the ship and joined the DDG during a recent port call several days ago in Guam. The Sailor was treated for constipation six days prior at the U.S. Naval Hospital in Guam and subsequently released after symptoms resolved following administration of a saline enema. Now, he complains of severe abdominal pain and subjective fever. He was brought to medical by his leadership, who is concerned that he seems confused today. He notes poor appetite for the duration of symptoms, nausea, and multiple episodes of emesis over the last 6 hours.

Past Medical History: Asthma. Not currently on inhalers. Approximately 12 months ago, he was hospitalized for seven days with COVID-19 pneumonia, where he received remdesivir and dexamethasone and returned to full duty.

Time 0 minutes (min)

Presenting vital signs: heart rate (HR) 130 beats per min (bpm); blood pressure (BP) 92/65mmHg; respiratory rate (RR) 30 breaths/min; peripheral oxygen (O_2) saturation (SpO_2) 92%; temperature (temp): 39°C; body mass: approximately 70kg.

Physical Exam: Confused, thinks he is in Recruit Training. Opens eyes spontaneously and follows simple commands. Appears to be in distress, with nasal flaring and increased work of breathing. The abdomen is distended, with voluntary guarding and diffuse tenderness to palpation; he is most tender in the right lower quadrant. Skin is cool to the touch; peripheral capillary refill time (CRT) is greater than 4 seconds assessed at the ventral surface of his right index finger. (Peripheral CRT assessed at the nailbed (Box 1) is as effective as serum lactate when used to target fluid resuscitation in septic patients).[13–18]

BOX 1 *Diagnostic Maneuvers and Procedures Utilized in this Sepsis Scenario*

Capillary Refill Time (CRT):[15–20]
- The index finger is commonly used. A normal nailbed capillary refill takes less than two seconds, and the upper limit of normal is less than three seconds.
- Press on the ventral surface of a distal phalanx for 10 seconds.
- Release and time how long it takes for normal color to return on the ventral surface of the phalanx.

Passive Leg Raise Test (PLR):[21]
- Avoid inducing pain or sympathetic stimulation that will increase the heart rate.
- Use the bed to place the patient's head up at 45 degrees. Measure and record blood pressure after approximately 90 seconds.
- Use the bed to place the patient supine at 0 degrees in the recumbent position. Next, raise both legs 45 degrees and hold for 90 seconds. Measure and record blood pressure. (It is ideal to use the bed to elevate the legs; if you cannot, manually elevate the patient's legs).
- Put the legs back down and raise the head of the bed to 45 degrees. Measure and record blood pressure after approximately 90 seconds (should return to baseline).

The recommended interventions include:

- While an abdominal source of infection is likely, a complete physical exam should be performed to rule out other causes of sepsis.
- Remove clothes and inspect the skin, groin, and axillae, looking for cellulitis or signs of infection or abscess.
- Take off boots and socks and inspect feet, checking between toes. Inspect feet and lower extremities for cellulitis or evidence of infection.
- Perform a digital rectal exam and inspect the gluteal cleft to look for evidence of perianal or perirectal abscess or pilonidal abscess with cellulitis.
- Ultrasound the abdomen for evidence of abdominal fluid collection. (Note: DDG medical departments do not have ultrasound capability).
- Determine NEWS Score – National Early Warning Score (Table 1). NEWS score=11.

Diagnosis

This patient has evidence of sepsis and potentially septic shock. Based on fever and peritonitis, he has suspected infection from an intra-abdominal source. There is evidence of circulatory dysfunction based on hypotension, tachycardia, and delayed CRT. The tachypnea is also concerning. There was no evidence of cellulitis or abscess on physical exam. His delirium is a strong warning sign: delirium is organ failure (in this case, brain failure), and delirium in the setting of an acute infection means that the patient is likely to be septic.

Sepsis Treatment Principles[3,4,10]

Early recognition of impending sepsis and immediate treatment with antibiotics are imperative to improve the chances of survival. Maintain high suspicion for signs of early and progressing sepsis while performing continuous triage. In severely hypotensive patients (MAP <65mmHg), fluid resuscitation is the priority. Ideally, antibiotics and fluid resuscitation should be administered simultaneously.

The recommended interventions include:

1. Early antimicrobial therapy.
2. Fluid resuscitation.
3. Source control.
4. Patient monitoring through trending patient information.
5. Early telemedicine consultation.
6. Evacuate to definitive care.

Probable Source of Infection

Given the physical exam, it is likely the abdomen. Therefore, source control is not possible onboard the ship. The Sailor will ultimately need surgical or procedural intervention.

Differential Diagnosis

Perforated appendicitis is most likely. Perforated diverticulitis and complicated cholecystitis are also possible. Pyelonephritis is less likely. Cellulitis or necrotizing soft tissue infection is unlikely based on a physical exam; however, this should always be a consideration in a septic patient with an unknown source. Consider endemic infections based on recent travel and port calls. Given that he joined the ship in Guam, consider leptospirosis or dengue fever.

The recommended interventions include:

- Continuous patient monitoring, including HR, BP, MAP, and pulse oximetry.
- Intravenous (IV) access × 2. 18 gauge or larger is recommended. If unobtainable, consider intraosseous (IO) access for the initial resuscitation and attempt IV after resuscitation.
- Immediately after identification of a septic patient, perform an initial rapid infusion of 30mL/kg with normal saline (NS) or lactated Ringer (LR) solutions. LR may be preferable if available, but both are acceptable. If the patient does not have an appropriate UOP response after the initial fluid bolus, the patient may need another 30mL/kg bolus.
- Continue LR or NS to maintain a goal urine output (UOP). *Goal UOP:* 0.3–0.5mL/kg/h. Increase or decrease fluid rate by 20%. However, if UOP is inadequate, the patient may need fluid bolus or another intervention (see below). LR is preferred over NS.
- *Early antibiotics:* Need to determine the most likely source based on history, physical exam, and imaging.
- Antibiotics for sepsis from a likely abdominal source. *Better:* TCCC antibiotics: ertapenem 1g IV every 24h. *Best:* ceftriaxone 2g IV/IO every 24h, PLUS metronidazole 500mg IV/IO/by mouth every 8h. Vancomycin 1.5mg/kg IV/IO every 12h could be considered, but it may not be necessary if an abdominal source is likely. Furthermore, it is unavailable on Cruisers or Destroyer (CRUDES) platforms. Discuss patient via telemedicine consultation.
- *Laboratory data.* While the following will help obtain clinical information, none of these labs are lifesaving and should not delay the initial therapy of antibiotics and IV fluids: CBC, urine analysis, blood glucose. (Note: Metabolic panel not available on CRUDES platforms).
- Supplemental O_2 by nasal cannula if hypoxemic (e.g., SpO_2 <92%).
- *Pain medication:* Unable to give oral medications due to gastrointestinal symptoms.
- Consider IV narcotics such as morphine, but this may cause hypotension early on (see below). If giving IV morphine, give during fluid bolus to avoid hypotension.

TABLE 1 *Physiologic Parameters and NEWS Score**

Physiologic parameters	3	2	1	0	1	2	3
RR (breaths/min)	≤8		9–11	12–20		21–34	≥25
Oxygen saturation (%)	≤91	92–23	94–95	≥96			
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	
Systolic BP (mmHg)	≤90	91–100	101–110	111–219			
HR (beats/min)	≤40		41–50	51–90	91–110	111–130	≥131
Level of consciousness				Alert			V, P, U

*Adapted from the Prolonged Casualty Care Clinical Practice Guidelines.[5] For the level of consciousness determination: A=Alert; V=Not alert but arouses to verbal stimulation; P=Not alert but responds to painful stimulation; U=Unresponsive.
NEWS = National Early Warning Score; RR = respiratory rate; BP =blood pressure; HR = heart rate.

This patient clearly needs fluid resuscitation. However, a passive leg raise (PLR) test can be performed to assess the need for fluid resuscitation after initial resuscitation, as the maneuver provides a temporary natural fluid bolus by returning venous blood to the central circulation. It is ideally assessed with advanced hemodynamic monitoring (beyond a BP cuff) but may be a valuable physical exam tool during PCC (Box 1).[19]

Time +90min

- 3L NS given, antibiotics given, IV fluids rate: NS at 125mL/h.
- HR 120bpm; BP 87/55mmHg; RR 25 breaths/min; SpO_2 92% on room air; temp 39.5°C.
- Urine output 15mL (dark in color).
- Alert and oriented, answering questions appropriately.
- White blood cell count (WBC): 21,000/µL; hemoglobin (Hgb) 15g/dL; hematocrit (HCT) 45%; platelet count (Plt) 485,000/µL.
- Abdomen is still distended with persistent nausea and three episodes of emesis. (Ileus or small bowel obstruction related to intra-abdominal abscess).

The recommended interventions include:

- *Nasogastric tube placement*. (Note: not available on DDG).
- Urinary catheter placement for urine output (UOP) monitoring. *Goal UOP:* 0.3–0.5mL/kg/h.
- *Telemedicine consultation*. Start vasopressors If available.
- *Initiate vasopressors*. Norepinephrine is preferred. Titrate to goal MAP >65mmHg. Vasopressors should be administered by role-based approved protocols or teleconsultation approval.
- *Norepinephrine drip range:* 2–20µg/min, titrate up or down by 2µg every 2–5min as needed (*pro re nata* or as needed). *Onset:* rapid, peak: 1–2min. *(Note: not available on DDG)*.
- *Epinephrine drip range (Table 2):* 1–10µg/min, titrate up or down by 1µg. *Onset:* rapid, peak: 1–2min. *(Note: only epinephrine 1:1000 vials on DDG)*. To dilute to 1:10,000, mix 1mg/mL ampule (1:1000) with 9mL of NS.
- Ensure unimpeded flow of vasopressor and check IV site frequently for any signs of extravasation (blanching of skin over vein, hardness of vein, and pallor to extremity). Check the IV site that is infusing vasopressor hourly.
- Label the bag with the type of medication, concentration, and the time and date initiated.
- Other medications may be advisable based on the recommendations below.

Pain control:

- Acetaminophen for pain control (it has no benefit for treating fever unless pyrexia; temp >39.5°C). Max dose 1g every 6h.
- Avoid non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen due to the risk of renal impairment.
- May need morphine 2–4mg IV every 3–4h, as needed for pain control. If hypotension develops after morphine, the patient is likely under-resuscitated and needs an IV fluid bolus.
- If the patient has persistent pain and tolerates oral (give instead of acetaminophen): acetaminophen/codeine (300mg/30mg): 1–2 tabs orally every 4–6h, as needed. *(Note: no other oral narcotic medication is available on DDG)*.

Chemical Venous Thromboembolism (VTE) Prophylaxis:

- Minimum: aspirin (oral).
- Better: heparin 5,000 units subcutaneously three times a day. (Note: Heparin is not available on DDG. Heparin is preferred in patients with renal insufficiency).
- Best: enoxaparin 30mg subcutaneously daily. (Note: only 10 doses of 30mg injection are available on DDG). *Use with telemedicine consultation. Use with caution if there are renal impairment concerns.*

Nausea/Vomiting

- *Consider ondansetron:* 1–2 tabs oral/sublingual every 4–6h as needed; or 4mg IV, may repeat once in 2h if nausea/emesis returns.
- Check the QT interval on the monitor/electrocardiogram before considering ondansetron administration because blood electrolytes may be abnormal with nausea or vomiting. *(Note: No electrocardiogram or three-lead cardiac monitoring is available on DDG)*.
- Gastrointestinal prophylaxis medications are probably not indicated in this patient. If the patient requires intubation, he may benefit from such medications. Minimum: ranitidine or famotidine oral. Better: omeprazole oral. Best: pantoprazole IV/oral or H_2 receptor blockers IV/oral. *(Note: not available on DDG)*.

Routine Nursing Care

- Plan for nursing and daily progress note documentation.[20]
- Document full assessment and nursing progress notes for significant events, as needed.
- Maintain head of bed elevation >30 degrees.
- After initiating vasopressors, BP readings need to be taken every 5min for proper titration for the first 30min and then every 15–30min for the next 2–3h. All other vital signs should be recorded hourly.
- Depending on the patient's ability to move, consider repositioning every 2h. Given that vasopressors are currently being titrated, the patient is not likely a candidate for ambulation.

Time: +8h

- HR 110 bpm; BP 98/66mmHg; RR 25 breaths/min; O_2 saturation 96% on room air; temp 38.5°C.

TABLE 2 *Epinephrine 4µg/min (1:10,000) Bag Reference Chart**

Normal saline bag size (0.9% NaCl)	Add to bag epinephrine 1:10,000	Starting dose, µg/min	Drip set: 10 drops/mL Drip rate: drops/min	Drip set: 15 drops/mL Drip date: drops/min
50mL	1mL (100µg)	4	20 drops/min	30 drops/min
100mL	2mL (200µg)	4	20 drops/min	30 drops/min
250mL	5mL (500µg)	4	20 drops/min	30 drops/min
500mL	10mL (1mg)	4	20 drops/min	30 drops/min
1000mL (1L)	20mL (2mg)†	4	20 drops/min	30 drops/min

*Adapted from Prolonged Casualty Care Clinical Practice Guidelines.[5,9]
†Not recommended. Commits a high volume of epinephrine to a large bag of intravenous fluids; may waste intravenous fluids if epinephrine needs to be discontinued.
NaCL = sodium chloride.

- *IV fluids rate:* LR at 125mL/h.
- *Epinephrine:* 8µg/min.
- UOP improved after initiation of vasopressors.
- *Cumulative total UOP:* 135mL (dark), approximately 20mL/h after initiating vasopressors.
- *Nasogastric tube (NGT) output:* 2L out after initial placement. Since placement 200mL. *(Note: NGT is not available on a DDG).*
- Patient is complaining of severe abdominal pain. Morphine 4mg IV was given, but he developed hypotension with a systolic BP (SBP) of 82mmHg and confusion a few min later.

The recommended interventions include:
- Consider the PLR test to correlate other signs indicating the need for further resuscitation.
- LR or NS fluid bolus 30mL/kg.
- Titrate vasopressors with a SBP goal >90mmHg or MAP >65mmHg.
- *Goal UOP:* 0.3–0.5mL/kg/h.
- NGT to low continuous or intermittent suction (if available).

Recommended Nursing Care:
- Maintain head of bed elevation >30 degrees.
- Check BP readings hourly or more frequently if frequent titration of vasopressors is needed.
- Check the IV site that is infusing vasopressor hourly.
- Document strict intake and output (I&Os) to track the patient's fluid status.
- Ensure patient is being repositioned or ambulated (if able) every 2h.
- Encourage coughing and deep breathing hourly.
- Assist patient with oral/dental care.

Time: +24h

The patient was given three 30mL/kg fluid boluses over the 16h with an initial good response. IV fluids rate turned down to 75mL/h at Time+12h. Over the last 6–8h, HR, and RR have increased and UOP and BP have decreased, causing you to increase the norepinephrine drip rate approximately hourly.
- HR 119bpm; BP 84/60mmHg; RR 25–30 breaths/min; O_2 saturation 94% on room air; temp 38.8°C.
- *Epinephrine:* 24µg/min.
- *IV fluids rate:* LR at 75mL/h.
- *Cumulative total IV fluid input:* 11,762.5mL (11.8L).
- *Cumulative total UOP:* 375mL over 24h. 10mL/h over the last 6h; brown.
- *Cumulative NGT output:* 3.7L over 24h; green, bilious.
- Unable to run more laboratory data.
- Abdominal pain is well controlled with scheduled acetaminophen and as needed IV morphine.
- No flatus, frequent burping.
- No change or increase in BP with PLR test.

Assessment:
- Likely appropriately resuscitated.
- Still with ileus/small bowel obstruction secondary to intra-abdominal infection.
- Consider the possibility of refractory shock and possible adrenal insufficiency.

Recommended Interventions:
- Telemedicine consultation. *Options:* Add a second vasopressor (epinephrine) if the initial vasopressor is norepinephrine *(Note: norepinephrine not available on DDG)*; or initiate stress dose steroids. Hydrocortisone is the preferred steroid in vasopressor refractory shock; however, it is typically not available to Role 1 medical departments at sea. Dexamethasone may be useful and is available. Decision: Dexamethasone 8mg IV daily.
- *IV fluids rate:* LR at 75mL/h.
- *Goal UOP:* 0.3–0.5mL/kg/h.
- Titrate vasopressors with a SBP goal >90mmHg or MAP >60mmHg.
- Continue NGT to low continuous or intermittent suction.
- Continue antibiotics and chemical VTE prophylaxis.
- The antibiotics may need to be re-dosed, depending on the type. Ertapenem and ceftriaxone are re-dosed every 24h; metronidazole is re-dosed every 8h.

Recommended Nursing Care:
- Maintain head of bed elevation >30 degrees.
- Check BP readings hourly or more frequently if frequent titration of vasopressors is needed.
- Cleanse the NGT site.
- Check the IV site that is infusing vasopressor hourly.
- Flush any IV line not being used every 12h.
- Perform Urinary Catheter care.
- Document strict intake and output (I&Os) to track the patient's fluid status.
- Ensure the patient is being repositioned or ambulated every 2h.
- Encourage coughing and deep breathing hourly when awake.
- Assist patient with oral/dental care.

Time: +48h

The patient was given one 30mL/kg fluid bolus 18h ago with a good response. IV fluids rate turned down to 50mL/h at Time+26h. Over the last 12h, HR, UOP, and BP improved; however, RR and respiratory distress increased. Eight hours ago, you started supplemental O_2 by nasal cannula for a SpO_2 of 88%.
- HR 97bpm; SBP 112/78mmHg; RR 35 breaths/min; O_2 saturation 94% on 8L; temp 38.5°C.
- *Norepinephrine:* 4µg/min (20 drops/min).
- *IV fluids rate:* LR at 50mL/h.
- *Cumulative total IV fluid input:* 15,112.5mL (~15.1L); 3,350mL over 24h.
- *Cumulative total UOP:* 1,035mL; 670mL over 24h. 35mL/h over the last 6h; yellow.
- *Cumulative NGT output:* 5.3L; 1.5L over 24h.
- Unable to run more laboratory data.
- Abdominal pain is well controlled with scheduled acetaminophen and as needed IV morphine.
- No flatus, frequent burping.
- No change or increase in BP with PLR test.

Assessment:

Pulmonary edema from resuscitation versus sepsis-induced lung injury. Still with ileus/small bowel obstruction secondary to intra-abdominal infection.

Recommended Interventions:
- Monitor airway and breathing closely.[21]
- Telemedicine consultation.
- *IV fluid rate:* LR at 50mL/h.
- Goal UOP: 0.3–0.5mL/kg/h.
- Titrate vasopressors with a SBP goal >90mmHg or MAP >60mmHg.

- Titrate O_2 to >92% SpO_2; consider a simple face mask if requiring >8L of O_2.
- Continue NGT to low continuous or intermittent suction.
- Continue dexamethasone, antibiotics, and chemical VTE prophylaxis.
- Appropriate re-dosing of antibiotics.

Recommended Nursing Care:
- Assist patient with skincare/bed bath.
- Maintain head of bed elevation >30 degrees.
- Check BP readings hourly or more frequently if frequent titration of vasopressors is needed.
- Cleanse the NGT site.
- Flush any unused IV line every 12h; check the IV site that is infusing vasopressor hourly.
- Perform Urinary Catheter care.
- Document strict intake and output (I&Os) to track the patient's fluid status.
- Ensure the patient is being repositioned or ambulated every 2h.
- Encourage coughing and deep breathing hourly when awake.
- Assist patient with oral/dental care.

Time: +72h

The patient no longer requires fluid boluses. Unable to wean off epinephrine but at a stable rate. RR improved with interventions and was able to titrate down supplemental O_2. Notified that MEDEVAC is available in 12h.
- HR 92bpm; BP 100/68mmHg; RR 22–28 breaths/min; O_2 saturation 94% on 4L via nasal cannula; temp 38.5°C.
- *Epinephrine:* 4µg/min.
- *IV fluid rate:* LR at 50mL/h.
- *Cumulative total IV fluid input:* 16,312.5mL (~16.3L); 1200mL over 24h.
- *Cumulative total UOP:* 1,635mL; 600mL over 24h. 30mL/h over the last 12h; yellow.
- *Cumulative NGT output:* 6.6L; 1.3L over 24h. Starting to clear up, but still light green.
- Unable to run more laboratory data.
- Abdominal pain is well controlled with scheduled acetaminophen and as needed IV morphine.
- No flatus, less burping.

Recommended Interventions:
- *Telemedicine consultation.* If diuretics are given, it should only be done in conjunction with a telemedicine consultation.
- Continue current care.
- Continue dexamethasone 8mg IV daily (prior steroid history).
- *IV fluids rate:* LR at 50mL/h.
- *Goal UOP:* 0.3–0.5mL/kg/h.
- Titrate vasopressors with a SBP goal >90mmHg or MAP >60mmHg.
- Titrate O_2 to >92% SpO_2.
- Continue dexamethasone, antibiotics, and chemical VTE prophylaxis.
- Appropriate re-dosing of antibiotics.

Recommended Nursing Care:
- Consider changing IV dressings if needed.
- Assist patient with skincare/bed bath.
- Maintain head of bed elevation >30 degrees.
- Check BP readings hourly or more frequently if frequent titration of vasopressors is needed.
- Cleanse the NGT site.
- Flush any unused IV line every 12h; check the IV site that is infusing vasopressor hourly.
- Perform Urinary Catheter care.
- Document strict intake and output (I&Os) to track the patient's fluid status.
- Ensure patient is being repositioned or ambulates every 2h.
- Encourage coughing and deep breathing hourly when awake.
- Assist patient with oral/dental care.

Recommendations to prepare the patient for MEDEVAC
- Make copies of all documentation and labs to send to the en-route care (ERC) team.
- Provide the patient with eye and ear protection.
- Reinforce all tubes and lines with tape.
- Ensure all fluids/medication bags are labeled.
- Label all lines with tape approximately 6 inches from the IV site with the medication or type of fluid infusing to the site.
- Empty urinary catheter bag.
- Consider administering 4mg IV ondansetron (Zofran) before flight.
- Re-dose pain medication before flight, anticipating that pain will increase due to the stressors of flight.
- Review the Medication Administration Record with the ERC team.

Discussion

This hypothetical scenario describes the management of a patient with septic shock from an abdominal source that is most likely acute perforated appendicitis. Most military general surgeons have managed a patient with sepsis from perforated appendicitis, particularly in the operational environment. In the active-duty population, the overall incidence rate of appendicitis is 18.4 per 10,000 person-years, and nearly 14% of patients present with perforation.[22] Between 1987 and 2017, appendectomy was the second most common major operation performed by U.S. Navy general surgeons deployed on warships (who manage all acute surgical diseases for the embarked crews on the various warships deployed in carrier and expeditionary strike groups).[23–26] Sailors and Marines with appendicitis have been impacting naval operations for decades. During World War II, "probably no other single disease caused more anxiety to submarine personnel than appendicitis." It was diagnosed by submarine pharmacist's mates (the precursors to Independent Duty Corpsmen) during 116 war patrols, and a submarine had to come off combat patrol or leave their area of operation in 11 (9.5%).[27]

As demonstrated in this scenario, the key principles in managing the septic patient include rapid identification of potential sepsis, early administration of antibiotics, early fluid resuscitation, source identification, and source control. While early antibiotics have demonstrated a mortality benefit in septic patients, appropriate fluid resuscitation should not be delayed for antibiotic administration; ideally, both are given simultaneously. A complete history and physical exam are critical to determining a potential source to aid the forward-deployed caregiver in antibiotic selection. While not exhaustive, Box 2 lists common causes of sepsis to consider. Also, consider endemic infectious diseases in the area of deployment or recent port calls.

In this scenario, acute perforated appendicitis is the cause of septic shock, but in the deployed environment SSTIs are also

common. While most SSTIs are managed on an outpatient basis, if not recognized and treated appropriately, sepsis and life-threatening shock can develop. Cellulitis and abscesses account for over two-thirds of all active-duty SSTI diagnoses and most hospital admissions for SSTI. The most common site is the lower extremity (33.6%), followed by the upper extremity (28.3%), trunk (14.2%), other or unspecified location (12.4%), and the head/face/neck region (11.5%).[28] Lower extremity SSTI are often missed, because caregivers do not examine the lower legs, feet or between toes during initial physical examinations.

BOX 2 *Potential Causes of Sepsis*

Head and neck infections
- Peritonsillar cellulitis and abscess
- Submandibular abscess and Ludwig angina

Pulmonary infections
- Bacterial pneumonia
- Coronavirus disease 2019 (COVID-19)

Gastrointestinal infections
- Appendicitis
- Sigmoid diverticulitis
- Cholecystitis
- Cholangitis

Skin and soft tissue infections
- Cellulitis
- Abscess
- Pilonidal abscess
- Perirectal/perianal abscess
- Necrotizing soft tissue infection

Urinary tract infection
- Cystitis
- Pyelonephritis

Gynecologic infection
- Bartholin abscess
- Pelvic inflammatory disease (e.g., tubo-ovarian abscess)

Most SSTIs are caused by *Staphylococcus* or *Streptococcus* species, typically acquired when military members live and work together in deployed or training environments. Risk factors for SSTI include crowded living conditions, infrequent bathing and hand washing, trauma (including minor skin abrasions), skin colonization, and environmental contamination, all common in the deployed shipboard environment.[29] The incidence of SSTI in the deployed maritime environment is not known. However, a 2011 study of 400 Sailors and Marines during a 3-week underway period found that 49.5% were colonized with *Staphylococcus aureus* and 3.5% with methicillin-resistant *S. aureus* (MRSA).[30] For comparison, as many as 30% of the U.S. population in colonized with *S. aureus*[31] and MRSA colonization rates of 1%–3% have been reported in different industrialized countries.[32]

Many potential causes of sepsis (Box 2) require surgical or procedural source control, which is typically not possible on Role 1 capable warships and submarines. However, superficial skin and soft tissue abscesses, pilonidal abscesses, and perirectal abscesses may all be encountered in deployed environments and Role 1 caregivers should be prepared to perform routine incision and drainage either to prevent the progression of infection to sepsis or for possible source control when rapid MEDEVAC is not possible. Box 3 lists the key references used to develop this scenario for those interested in further reading; these are easily accessed electronically or via military treatment facility libraries and should be readily available when deployed in the austere maritime environment.[3,4,7,10,20,21,33–37]

BOX 3 *Readily Available Sepsis and Critical Care Management Resources*

Joint Trauma System (JTS) Clinical Practice Guidelines (CPG). Most up to date CPGs available at: https://jts.health.mil/index.cfm/PI_CPGs/cpgs or at https://deployedmedicine.com
- Tactical Combat Casualty Care (TCCC) Guidelines
- Prolonged Casualty Care Guidelines
- Sepsis Management in Prolonged Field Care
- Infection Prevention in Combat-related Injuries
- Documentation In Prolonged Field Care
- Airway Management in Prolonged Field Care
- Nursing Intervention in Prolonged Field Care
- Telemedicine Guidance in the Deployed Setting

Other Relevant Resources:
- Evans L, Rhodes A, Alhazzani W, et al. Surviving Sepsis campaign: International guidelines for management of sepsis and septic shock 2021. *Crit Care Med*. 2021;49(11):e1063–e1143.
- Carr MJ, Maves RC. Infectious disease pearls for maritime surgical teams. In: Tadlock MD, Hernandez AA, eds. Expeditionary Surgery at Sea: A Practical Approach. Springer; 2023:267–285.
- Biberston JD, Darling JA, Tripp MS. Maritime prolonged casualty care. In: Tadlock MD, Hernandez AA, eds. Expeditionary Surgery at Sea: A Practical Approach. Springer; 2023:611–626.
- Burkholder T. Alone and unafraid: the independent duty corpsman at sea. In: Tadlock MD, Hernandez AA, eds. Expeditionary Surgery at Sea: A Practical Approach. Springer; 2023:173–188.

The patient in this scenario required vasopressor support for persistent low blood pressure related to septic shock, despite appropriate crystalloid resuscitation. In this situation, Norepinephrine is the first-line vasopressor recommended. Unfortunately, only epinephrine is available on destroyers (in vials with a 1:1,000 concentration). Therefore, Role 1 maritime caregivers must understand how to mix an epinephrine drip and estimate the µg/min being administered by calculating the drip rate (Table 2). Correctly mixing and administering a vasopressor drip by calculating the drip rate requires training before deployment. Box 1 lists other necessary procedures in this scenario that also require specific training before being performed in an austere environment.

While vasopressors are routinely started through peripheral IVs in an emergency, central venous access is routinely obtained if prolonged vasopressor use is required. However, in the austere setting, most Role 1 caregivers lack the supplies and the skillset to obtain central venous access. Therefore, peripheral antecubital access is acceptable. However, the access site MUST be inspected with every vital sign check for evidence of infiltration of the vasopressor into the surrounding tissues. Infiltration typically manifests as swelling, redness, or induration at the venous access sight; it can cause permanent damage to the vessel or even compartment syndrome to the extremity.

In addition to norepinephrine, several medications, supplies, and equipment recommended in this scenario are unavailable on U.S. Navy destroyers, cruisers, or submarines. These include ultrasound, electrocardiogram, three-lead cardiac monitoring, nasogastric tubes, IV hydrocortisone, and subcutaneous heparin. To prepare Independent Duty Corpsmen to perform PCC during LSCO or routine Distributed Maritime Operations, we identified four changes to the Role 1 capable warship Authorized Medical Allowance List (AMAL) that should be considered.

First, it is hard to argue that norepinephrine or IV hydrocortisone should be included on AMALs, given how infrequently

they would be used. Furthermore, the epinephrine vials in the AMAL may be utilized for other emergencies, such as Advanced Cardiac Life Support or anaphylaxis.

However, given that there is no ability to measure electrolytes and hyperkalemia, adding three-lead cardiac-monitoring capability should be considered. Second, as there is no ability to measure renal function, renally cleared drugs, particularly enoxaparin, should be used with caution in patients at risk for acute kidney injury. Subcutaneous heparin may be a more versatile drug for chemical VTE prophylaxis in austere environments where renal function (beyond UOP) cannot be monitored.

Next, Distributed Maritime Operations is not a future operating concept. It is happening now during current routine naval operations. As such, having a few nasogastric tubes on board may be beneficial for decompression of ileus related to abdominal infections, small bowel obstruction, or for enteral hydration and resuscitation in patients unable to take in fluids by mouth during PCC. Finally, the lack of ultrasound equipment and training on smaller naval vessels must be addressed. Historically, ultrasound capability has not been available because of limited space and the potential cost of equipment and training. However, modern hand-held ultrasound devices are ubiquitous in civilian hospitals and would benefit austere caregivers, particularly during Distributed Maritime Operations. With the appropriate training, ultrasound is useful in assisting with IV access, diagnosing cardiac, pleural, and intra-abdominal pathology from trauma and disease non-battle injury, and identification of subcutaneous abscesses.

Preparing Independent Duty Corpsmen and other Role 1 caregivers for the type of situation described in this scenario does not mean that keeping a critically ill patient like this on the ship should become routine practice. After initial resuscitation, the patient's life-threatening condition should be clearly communicated up the chain of command in a respectful manner that emphasizes the gravity of the situation. As the mission, operational environment, and situation allow, every opportunity should be made to MEDEVAC this type of patient to a higher level of care as soon as possible.[38]

Finally, as discussed in the introduction to this collection of maritime PCC scenarios, the vast majority (90%) of U.S. Navy Role 1 capable ships are led by Independent Duty Corpsmen who receive no routine clinical experience or skills sustainment relevant to sepsis management, critical care, or PCC. Given this, Role 1 maritime caregivers need both a PCC training curriculum (including specific procedural training) and routine clinical experiences (in intensive care units and hospital wards providing basic medical and nursing care foundational to PCC) to perform PCC during current operations and a future war at sea.

Author Contributions

MDT and MST conceived the study concept. MDT, MST, and RCM performed the literature review and developed the scenario. MDT drafted the original manuscript. MDT, RCM, DMF, TJB, DA, JCR, LKK, JJB, and MST participated in critical revisions.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, the Department of Defense, or the U.S. Government.

Disclosures

The authors declare no funding or conflicts of interest.

Funding

No funding was received for this work.

This scenario and the project "Maritime Applications of Prolonged Casualty Care" were presented at the Special Operations Medicine Association 2023 Scientific Assembly on 18 May 2023 in Raleigh, North Carolina.

References

1. **Tadlock MD, Kitchen LK, Brower JJ, Tripp MS.** Maritime applications of prolonged casualty care: a series introduction. *J Spec Oper Med*. Published online March 13, 2024. doi:10.55460/GOPF-AS1O
2. **Remley MA, Riesberg JC, Drew B, et al.** Committee on Tactical Combat Casualty Care and Prolonged Casualty Care Working Group consensus statement. *J Spec Oper Med*. 2023;23(2):124–125. doi:10.55460/woca-6w0t
3. **Remley M, Paul Loos P, Riesberg, J.** Prolonged Casualty Care Guidelines (PCC) – CPG ID 91. Joint Trauma System. December 21, 2021. Accessed July 11, 2023. https://jts.health.mil/assets/docs/cpgs/Prolonged_Casualty_Care_Guidelines_21_Dec_2021_ID91.pdf
4. **Evans L, Rhodes A, Alhazzani W, et al.** Surviving Sepsis campaign: International guidelines for management of sepsis and septic shock 2021. *Crit Care Med*. 2021;49(11):e1063–e1143. doi:10.1097/ccm.0000000000005337
5. **Dellinger RP, Rhodes A, Evans L, et al.** Surviving Sepsis campaign. *Crit Care Med*. 2023;51(4):431–444. doi:10.1097/ccm.0000000000005804
6. **Marshall JC, Bosco L, Adhikari NK, et al.** What is an intensive care unit? A report of the task force of the World Federation of Societies of Intensive and Critical Care Medicine. *J Crit Care*. 2017;37:270–276. doi:10.1016/j.jcrc.2016.07.015
7. **Barsoumian LCA, Solberg MS, Maves RC, et al.** Infection prevention in combat-related injuries – CPG ID: 24. Joint Trauma System. January 27, 2021. Accessed 2023. https://jts.health.mil/assets/docs/cpgs/Infection_Prevention_in_Combat-related_Injuries_27_Jan_2021_ID24.pdf
8. **Arnold K, Cutting RT.** Causes of death in United States military personnel hospitalized in Vietnam. *Mil Med*. 1978;143(3):161–164.
9. **Singer M, Deutschman CS, Seymour CW, et al.** The third international consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA*. 2016;315(8):801–810. doi:10.1001/jama.2016.0287
10. **Rapp J, Keenan S, Taylor D, et al.** Sepsis management in prolonged field care: 28 October 2020. *J Spec Oper Med*. 2020;20(4):27–39. doi:10.55460/I18B-1ZQM
11. **Snitchler CL, Patel DM, Stahlman SL, Chauhan AV, Wells NY, Mcquistan AA.** Sepsis hospitalizations among active component service members, US Armed Forces, 2011-2020. *MSMR*. 2021;28(11):2–8.
12. **Borgie RC, Pangco CA.** Shipboard diagnostics: laboratory and radiology. In: Tadlock MD, Hernandez AA, eds. *Expeditionary Surgery at Sea: A Practical Approach*. Springer; 2023:105–121.
13. **Castro R, Kattan E, Ferri G, et al.** Effects of capillary refill time-vs. lactate-targeted fluid resuscitation on regional, microcirculatory and hypoxia-related perfusion parameters in septic shock: a

randomized controlled trial. *Ann Intensive Care*. 2020;10(1):150. doi:10.1186/s13613-020-00767-4
14. **Hernández G, Ospina-Tascón GA, Damiani LP, et al.** Effect of a resuscitation strategy targeting peripheral perfusion status vs serum lactate levels on 28-day mortality among patients with septic shock: the ANDROMEDA-SHOCK randomized clinical trial. *JAMA*. 2019;321(7):654–664. doi:10.1001/jama.2019.0071
15. **Lara B, Enberg L, Ortega M, et al.** Capillary refill time during fluid resuscitation in patients with sepsis-related hyperlactatemia at the emergency department is related to mortality. *PloS One*. 2017;12(11):e0188548. doi:10.1371/journal.pone.0188548
16. **Hernández G, Cavalcanti AB, Ospina-Tascón G, et al.** Early goal-directed therapy using a physiological holistic view: the ANDROMEDA-SHOCK—a randomized controlled trial. *Ann Intensive Care*. 2018;8(1):52. doi:10.1186/s13613-018-0398-2
17. **Hernandez G, Pedreros C, Veas E, et al.** Evolution of peripheral vs metabolic perfusion parameters during septic shock resuscitation. A clinical-physiologic study. *J Crit Care*. 2012;27(3):283–288. doi:10.1016/j.jcrc.2011.05.024
18. **Ait-Oufella H, Bige N, Boelle P, et al.** Capillary refill time exploration during septic shock. *Intensive Care Med*. 2014;40(7):958–964.
19. **Monnet X, Teboul J-L.** Passive leg raising: five rules, not a drop of fluid! *Crit Care*. 2015;19(1):18. doi:10.1186/s13054-014-0708-5
20. **Loos PE, Glassman E, Doerr D, et al.** Documentation in prolonged field care. *J Spec Oper Med*. Spring 2018;18(1):126–132. doi:10.55460/id7f-q4we
21. **Dye C, Keenan S, Carius BM, et al.** Airway management in prolonged field care. *J Spec Oper Med*. 2020;20(3):141–156. doi:10.55460/baf7-3bm3
22. Appendicitis and appendectomies, active and reserve components, U.S. Armed Forces, 2002–2011. *MSMR*. 2012;19(12):7–12.
23. **Fisher RA, Dunn WD.** Peacetime surgery in the aircraft carrier battle group. *Mil Med*. 1990;155(7):332–334.
24. **Fontana M, Lucha P, Snyder M, Liston W.** Surgery aboard ship: is it safe? *Mil Med*. 1999;164(9):613–615.
25. **Lin H, Ancheta A, Uzcategui L, Plurad D.** Surgery in expeditionary strike group. *Mil Med*. 2009;174(3):241–244. doi:10.7205/milmed-d-03-6307
26. **Nealeigh MD, Kucera WB, Bradley MJ, et al.** Surgery at sea: exploring the training gap for isolated military surgeons. *J Surg Educ*. 2019;76(4):1139–1145. doi:10.1016/j.jsurg.2018.12.008
27. **Shilling CW, Kohl, JW.** History of Submarine Medicine in World War II, U.S. Naval Medical Research Laboratory. May 25, 1947. Accessed January 1, 2024. https://collections.nlm.nih.gov/catalog/nlm:nlmuid-35410810R-bk?_gl=1*2mpy7n*_ga*MTE4NTQxMzYwMS4xNzA1MjQ3MDUz*_ga_7147EPK006*MTcwNTI0ODU1MS4xLjEuMTcwNTI0ODY5NC4wLjAuMA..*_ga_P1FPTH9PL4*MTcwNTI0ODU1MS4xLjEuMTcwNTI0ODY5NC4wLjAuMA.
28. **Stahlman S, Williams VF, Oh G-T, Tribble DR, Millar EV.** Skin and soft tissue infections, active component, US Armed Forces, January 2016-September 2020. *MSMR*. 2021;28(4):27–38.
29. **Millar EV, Schlett CD, Law NN, et al.** Opportunities and obstacles in the prevention of skin and soft-tissue infections among military personnel. *Mil Med*. 2019;184(Suppl 2):35–43. doi:10.1093/milmed/usz105
30. **Curry JA, Maguire JD, Fraser J, et al.** Prevalence of Staphylococcus aureus colonization and risk factors for infection among military personnel in a shipboard setting. *Mil Med*. 2016;181(6):524–529. doi:10.7205/MILMED-D-15-00274
31. **Gorwitz RJ, Kruszon-Moran D, McAllister SK, et al.** Changes in the prevalence of nasal colonization with Staphylococcus aureus in the United States, 2001–2004. *J Infect Dis*. 2008;197(9):1226–1234. doi:10.1086/533494
32. **Piewngam P, Otto M.** Staphylococcus aureus colonisation and strategies for decolonisation. *Lancet Microbe*. Published online March 19, 2024;doi:10.1016/s2666-5247(24)00040-5
33. **Joint Trauma System.** Tactical Combat Casualty Care Guidelines. Accessed July 11, 2023. https://books.allogy.com/web/tenant/8/books/b729b76a-1a34-4bf7-b76b-66bb2072b2a7/
34. **Ostberg D, Loos P, Mann-Salinas E, et al.** Nursing intervention in prolonged field care. Joint Trauma System. July 22, 2018. Accessed July 11, 2023. https://jts.health.mil/assets/docs/cpgs/Nursing_Intervention_Prolonged_Field_Care_22_Jul_2018_ID70.pdf
35. **Robbins J, Pamplin J, Kile M, et al.** Telemedicine guidance in the deployed setting. Joint Trauma System. September 19, 2023. Accessed December 31, 2023.https://jts.health.mil/assets/docs/cpgs/Telemedicine_Deployed_Setting_19_Sep_2023.pdf
36. **Carr MJ, Maves RC.** Infectious disease pearls for maritime surgical teams. In: Tadlock MD, Hernandez AA, eds. *Expeditionary Surgery at Sea: A Practical Approach*. Springer; 2023:267–285.
37. **Biberston JD, Darling JA, Tripp MS.** Maritime prolonged casualty care. In: Tadlock MD, Hernandez AA, eds. *Expeditionary Surgery at Sea: A Practical Approach*. Springer; 2023:611–626.
38. **Burkholder T.** Alone and unafraid: the independent duty corpsman at sea. In: Tadlock MD, Hernandez AA, eds. *Expeditionary Surgery at Sea: A Practical Approach*. Springer; 2023:173–188.