# Needed Evolution in Afloat Teleradiology and Imaging Capabilities

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## Introduction

The concept of telemedicine dates back nearly 120 years, when William Einthoven won the Nobel Prize for transmitting the first EKG via telephone over 1.5 km.[1] Teleradiology has since evolved to allow specialists to review medical imaging remotely, facilitating faster and higher-quality patient care.[2] While ordering physicians can provide preliminary reads, the American College of Radiology recommends that all emergency department images be interpreted by a radiologist within 30–45 minutes, setting a gold standard that afloat care should strive to emulate.[3]

Plain film radiology has been available on amphibious naval vessels since the late 1980s. Over the past 35 years, advancements in afloat teleradiology have enabled medical teams to transmit images to shore for radiologist interpretation. These images guide patient management, influencing decisions on medical evacuation (MEDEVAC), duty status and treatment pathways. Teleradiology improves quality and efficiency, enhances time to treatment and refines treatment modalities, elevating care standards.[4] However, challenges remain in report turnaround time, radiologist availability, and imaging capabilities as we prepare for future Near Peer Adversary (NPA) conflicts.

## Improved quality and efficiency of care at sea

Teleradiology is an essential yet underappreciated tool in the austere shipboard medical environment. It is often assumed that embarked medical providers can interpret radiographs without immediate radiologist support and that delayed reports will not significantly impact patient care. However, this assumption must be challenged as naval forces prepare for future conflicts.

Several studies have highlighted teleradiology's impact on care quality. Archbold et al. found that teleradiology improved musculoskeletal injury management in 35 of 46 referrals and altered treatment for eight patients, leading to cost-effective care[5]. In resource-limited settings, approximately two-thirds of teleradiology consultations improve quality, with nearly one-quarter leading to changes in management[2,6]. This underscores teleradiology's role in reducing misdiagnosis and preventing inappropriate treatment.

Beyond reducing misdiagnosis, teleradiology minimises unnecessary MEDEVACs. Stoloff et al. reported that telemedicine, including teleradiology, influenced MEDEVAC decisions in over one-third of cases.[2] Another study demonstrated a reduced incidence of missed bone fractures and unnecessary patient transfers.[7] Unwarranted MEDEVACs deplete personnel, increase risk through helicopter transport, and drive up costs from host-nation hospital fees. Expanding teleradiology services through military and civilian partnerships can mitigate these issues, with service costs offset by overall savings.

The most important aspect of austere military care relates to both combat and non-combat-related trauma. Trauma care in austere military settings relies on rapid decision-making with limited clinical information.[8] An immediately available radiologist can provide critical interpretations of chest and pelvic radiographs, potentially determining life-saving interventions when shipboard providers have limited trauma imaging experience.

## Logistic considerations

Teleradiology's rapid expansion in the private sector over the past three decades has been driven by the need for after-hours coverage of urgent studies.[4] These services have reduced report turnaround times by up to 60% and decreased patient transport costs.[9,10] Additionally, teleradiology addresses the growing shortage of radiologists in austere and military settings.[11]

One key advantage of expanded teleradiology at sea is improved patient care, reducing unnecessary MEDEVACs and ensuring personnel remain mission-capable.[2] Teleradiology also allows images to be transmitted ahead of a patient's evacuation, enhancing medical decision-making at the receiving facility.[8]

However, challenges to include civilian teleradiology centres exist. Licensing requirements dictate that teleradiologists be licensed in both the state of care and image evaluation, complicating matters for shipboard patients at sea.[4] While this is not currently an issue with Department of Defense (DoD) radiologists, expanding services to private providers will require careful licensing agreements. Contracting with non-DoD entities will also necessitate considerations such as volume-based compensation models with bonuses and penalties as quality assurance measures.[4]

## Afloat teleradiology experience

We retrospectively reviewed the radiology report turnaround times on the USS Wasp between 15 February and 14 October 2024, which revealed significant delays. Of the 8-month review period, 6 months were spent deployed at sea, while 2 months were spent pier-side in the United States US. Data were collected from the ship's radiology log and MedWeb software (Burlingame, CA), measuring read times from image upload to report receipt.

The average read time was 7.6 days ± 0.6 days, increasing to 7.8 days ± 0.6 days during deployment. The standard deviation of approximately 12 days highlights the unpredictability of report turnaround. While shore-based systems routinely provide reads within 24 hours, shipboard delays represent a clear quality-of-care issue. Real-time diagnostic imaging access is crucial, particularly in operational environments where decisions must be made rapidly.

Walter Reed National Military Medical Center's (WRNMMC) Department of Radiology is solely responsible for processing all US Navy shipboard radiologic exams. Given the fleet's size, this creates a substantial workload. While a dedicated staff radiologist provides daily reports, no overnight coverage exists for consultation or official reports. This absence of 24/7 radiologist availability significantly limits capabilities. In future naval conflicts, where combat may occur at any hour, immediate radiologist consultation—independent of time zones—will be critical for medical teams making urgent care decisions.

Our ship's medical department experienced the largest mass casualty event at sea since 2017. Plain film radiology was the most utilised diagnostic tool, particularly for orthopaedic injuries. This event occurred outside normal radiology staffing hours, leading to delayed assessments. While one missed clavicular fracture did not result in patient harm, immediate radiologist access could have expedited care. Additionally, a pneumothorax patient required daily chest X-rays for monitoring, but lengthy report turnaround times made timely assessment impractical. These cases illustrate the need for off-hours teleradiology services to support shipboard providers in real time.

## Needed evolution: From improved consultation access to computed tomography afloat

Teleradiology is not a new technology, but its application in the US Navy has lagged behind civilian advancements. Fortunately, modern infrastructure can enhance shipboard radiology by reducing urgent image reporting times and improving communication between providers and radiologists.

The Navy should collaborate with private teleradiology firms to expand urgent image reading services. Relying solely on WRNMMC for fleet-wide radiologic interpretation places an excessive burden on a single department already tasked with supporting the largest tertiary military hospital in the world. Warships operate in remote maritime regions, often far from shore-based tertiary care centres. Given the unpredictable nature of shipboard medical care, access to civilian off-hours teleradiology services is essential for maintaining high-quality care.

Beyond expanded teleradiology, the most pressing need in shipboard radiology is the addition of computed tomography (CT) scanners on large-platform warships. CT imaging would enhance diagnostic accuracy, particularly for suspected appendicitis, traumatic brain injuries and cervical spine injuries.

Abdominal pain management in austere settings can also benefit significantly from CT imaging. Rosen et al. found that pre- and post-CT diagnoses matched in only 37% of cases, emphasising the value of CT in reducing diagnostic uncertainty.[12] When evaluating suspected appendicitis, CT imaging correlates with lower morbidity rates, regardless of final diagnosis.[13] Limited shipboard resources often lead to precautionary MEDEVACs, increasing costs and personnel losses.

In trauma settings, CT is now the gold standard for cervical spine evaluation, with plain radiographs offering an alarmingly low sensitivity of 45–60%.[14] In future conflicts, warships will serve as casualty receiving centres, where CT will be crucial for triaging and managing trauma patients.

Expanded teleradiology services would mitigate concerns about afloat providers interpreting CT scans without radiologist support. Adding CT

capabilities would improve adherence to trauma guidelines, reduce unnecessary MEDEVACs and provide long-term cost savings.

## Conclusion

Teleradiology is a crucial but underutilised tool for enhancing quality and efficiency in shipboard medical care. Warship-based providers would benefit from improved access to timely radiology consultations, allowing real-time decision making that could significantly impact patient outcomes. Beyond improved consultation efficiency, advancing shipboard imaging capabilities—mainly through the addition of CT—should be a priority in modernising naval medical departments.

CT could improve care quality, reduce diagnostic uncertainty and decrease the need for urgent MEDEVACs, ultimately lowering costs and increasing mission readiness. The Navy must continue to refine and expand its teleradiology services and shipboard imaging capabilities to provide the highest standard of care in future maritime conflicts.

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