Military Telemedicine

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Introduction

Within the health-care setting, telemedicine is defined as the practice of medicine when geographical distance or isolation separates the physician and patient. Often, this practice is achieved through the use of electronic communications systems, including video teleconferencing (VTC), digital imaging, e-mail, high-speed networks, and other forms of Internet technology [1, 2]. The application of telemedicine can improve patient access to health-care services by increasing the availability of medical specialists and by obviating the need for remotely located patients to travel long distances to receive care. Because it provides efficient health-care delivery without compromising the quality of that care, telemedicine is increasingly used to transmit medical information to specialists, who in turn respond with prompt medical recommendations regarding diagnosis and treatment.

Telemedicine can be applied to a broad range of medical specialties, including, but not limited to, neurology (referred to as teleneurology). The surge of teleneurology cases stems from the timely conjunction of a shortage of neurology specialists with recent advances in technology [3, 4]. In the past decade, teleneurology has been applied most often to emergency stroke care and to neurocritical care [5] but has evolved to include longitudinal care for chronic neurological conditions, such as epilepsy [6], Parkinson's disease [7], multiple sclerosis [8], dementia [9], and migraine headache [10].

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Neurology Telemedicine in the Military

Military health-care providers see a broad spectrum of neurological disorders but there are only a limited number of active duty neurology specialists to consult [11]. In particular, forward-deployed providers, such as those in Afghanistan, are often geographically dispersed in austere environments, have limited resources, and are in critical need of prompt specialist expertise in traumatic brain injury (TBI) and other complex neurological cases. In turn, cases that can be managed locally with the help of specialized knowledge and guidance can avoid costly and unnecessary medical evacuations that reduce unit readiness and are potentially hazardous when overflying enemy territory [12]. Telemedicine is, thus, a viable option to solve access to, to reduce the cost of, and to improve the quality of health-care delivery in the military's battlefield and operational theaters. In general, telemedicine in both the military and civilian spheres can be implemented in two ways: via videoconferencing and via a store-and-forward system.

Videoconferencing

Videoconferencing, or synchronous telemedicine, requires the use of audiovisual equipment that allows the consulting physician, on-site physician, and patient (if applicable) to confer in real time. For example, neurosurgeons at Walter Reed Army Hospital in Washington, DC, used videoconferencing equipment to monitor and advise neurosurgery conducted by general surgeons at a military hospital in Bagram, Afghanistan [13]. The lights above the operating table contained videoconferencing cameras that allowed the remotely located neurosurgeons to have a live view of the operation from the surgeon's perspective. However, videoconferencing operations experience notable time lags between the remotely located surgeon's suggestions and the in-theater surgeon's actual movements. This signal latency makes some emergency neurosurgical videoconferencing inadvisable, and, therefore, overcoming signal transmission latency should be a focus of future telemedicine endeavors.

Store and Forward

Store-and-forward, or asynchronous, telemedicine occurs between consulting and onsite/referring physician exclusively via e-mail. As defined by Poropatich and colleagues, teleconsultation is the specific act of "electronic exchange of patient demongraphics, medical history, and physical examination data between a medical provider (physician, nurse, or medic) and a medical specialist for the purpose of obtaining an expert opinion and/or advice and diagnostic support regarding the treatment of a patient" [14]. The e-mail from the referring physician may also include any relevant clinical pictures or radiological images, and the consulting physician

responds with diagnostic and treatment recommendations in a convenient and appropriately timed manner.

Benefits and Limitations of Telemedicine Systems

The military health-care system has taken advantage of both videoconferencing and store-and-forward telemedicine systems. The settings in which these systems are employed depend largely on the availability of required technology and on the schedule of the physicians involved. Live-feed videoconferencing systems allow for the neurologist to take a patient's history personally and to see the neurological exam performed. The real-time communication also means that a diagnosis can be achieved as quickly as a normal face-to-face interaction allows. However, videoconferencing systems are often more costly than store-and-forward systems, and, in a remotely located combat environment, coordinating physicians' and patients' schedules can prove difficult. Store-and-forward systems, on the other hand, are inexpensive and occur in a time frame that is convenient for both the referring and consulting health-care providers. The consulting physician must rely on the clinical skills of the referring provider and is unable to observe nonverbal factors related to the case at hand. These difficulties often result in multiple e-mails between referring and consulting physicians, which may delay the time it takes to achieve a final diagnosis. These hurdles are overcome as the physicians involved become more comfortable with providing sufficient information via store-and-forward telemedicine systems.

The US Army Online teleconsultation program was established using a store-and-forward e-mail-based system. When the program was designed in 2003–2004, it was envisioned as a short-term solution until a robust Internet-based system that linked the deployed physician to the Armed Forces Health Longitudinal Technology Application (AHLTA) and the patient's military health-care records. A prototype application was developed but never implemented due to bandwidth limitations in the 2004–2005 era. Users in 2005 overwhelmingly favored the e-mail-based system. Since then, the US Army Medical Department has utilized the store-and-forward Army Knowledge Online (AKO) teleconsultation program to provide guidance for deployed health-care providers regarding: (1) the treatment and diagnosis for atypical cases, (2) returning service members to full duty as soon as is safely possible, and (3) prevention of unnecessary medical evacuations out of theater [15]. The program provides a standardized electronic platform for managing acute and emergent care requests between forward-based providers and rear-based specialists. The platform can be used by all deployed medical personnel at operational medical facilities, which are at least minimally equipped with low bandwidth technology capable of e-mail. Nondeployed providers, patients, and patient family members are not permitted to use the teleconsultation service currently.

Since its inception with the departments of dermatology and ophthalmology, the AKO teleconsultation program has experienced rapid success. AKO has expanded to include 19 additional subspecialties, including the following (Table 1):

Table 1 List of specialties with consult groups

Specialty
Burn-Trauma
Cardiology
Dermatology
Dental
Infectious Diseases
Infection Control
Internal Medicine
Microbiology/Laboratory
Nephrology
Neurology
Ophthalmology/Optometry
Orthopedics/Podiatry
Pediatrics Intensive Care
Preventive Medicine
Rheumatology
Toxicology
Traumatic Brain Injury
Sleep Medicine
Urology

As of September 2012, more than 10,600 teleconsultations have been requested from more than 2600 providers from all four branches of the military deployed in more than 40 countries [16]. From October 2006 to December 2010, more than 500 of these teleconsultations were addressed to the military teleneurology consultation group and 131 to the TBI consultation group [17]. Most consultation requests were answered in less than 5 h, and approximately 143 known evacuations (3 neurology-specific) were avoided following receipt of the consultants' recommendations [17]. Thus, the AKO telemedicine system has successfully streamlined medical communications between military health-care providers and has led to a better evacuation mechanism (i.e., only evacuation of appropriate cases) in deployed health-care settings.

Current Use in Combat Settings

Technology Required

The austere environment of deployed settings necessitates the use of store-and-forward systems, and so the AKO teleconsultation program predominates as the telemedicine solution to specialty care in theater [15]. No specialized equipment is necessary to support this service. Instead, providers wishing to send a consultation request require only a Department of Defense (DoD) secure computer with Internet and e-mail capability. Most deployed providers also have their own digital camera

while deployed, obviating the need to supply cameras to in-theater health-care providers. Because operational medical facilities already own all the equipment necessary to facilitate the AKO teleconsultation program, the program remains both a safe and cost-effective way to obtain medical advice within the existing DoD network.

Telemedicine Team Members

The AKO telemedicine system consists of a range of clinical and administrative members who work together to ensure timely and proficient teleconsultations. These team members include the AKO consult manager (CM), the surgeon generals' medical specialty consultants, the AKO consultants, and the deployed providers.

The AKO CM serves as the "gatekeeper" of the teleconsultation service. The CM supports the daily operations of the service by monitoring consult activity for quality and timeliness. The CM, who has access to all telehealth communications within the AKO network, is familiar with medical terminology and ensures consult compliance with the Health Insurance Portability and Accountability Act (HIPAA; Public Law 104–191) and with the 24-h response time period mandated by the Office of the Surgeon General of the US Army. If necessary, a reminder is sent to the specialty if a teleconsultation is not answered within 12–18 h. Furthermore, the CM has a broad knowledge of digital imaging and information technologies, allowing the CM to troubleshoot technical problems with individual consultations. For example, military treatment facilities often block incoming and outgoing e-mails that exceed certain size limitations. Size limitations can hinder the transmission of medical images, such as radiographs or other supporting documentation, which are larger than the maximum 1–2 MB file size. In these cases, the CM can manually compress the image to the appropriate file size before retransmitting them to the appropriate provider. The CM may also contact the deployed provider directly to instruct him or her on how to adjust the camera resolution to maximize the utility of future consultations.

In addition to ensuring AKO teleconsultation guidelines, the CM also collects, records, and permanently stores all consult data according to specialty. The database is valuable in the support of follow-up consultations and in the generation of the CM's monthly, annual, and ad hoc reports. These reports include data analyses about the epidemiology of disease, number and type of consultation requests, consult response times, patient outcome, number of medical evacuations facilitated or avoided, and levels of provider satisfaction.

Finally, the CM is the central liaison between deployed providers and consultants. The CM trains and educates deploying providers about the AKO teleconsultation program and the rules of engagement. The CM also sends an introductory e-mail to new AKO consultants after they receive their first teleconsultation request. Through these interactions, the CM becomes aware of the geographic locations of all specialty consultants both inside and outside of the combat zone, and is able to route the consult requests to the appropriate locations. The CM can also facilitate collaboration by including multiple specialties—say neurology, ophthalmology, and TBI—in a single consultation request.

The surgeon generals' *medical specialty consultant* supervises his or her respective teleconsultation service. The medical specialty consultants recruit medical staff to answer teleconsultations and develop an on-call roster to ensure the scheduling and availability of consultants from all branches of service (Army, Navy, Air Force, Public Health Service). However, the medical specialty consultant position is optional within a specialty and depends on the availability and willingness of a team member to accept additional responsibility. The specialties of dermatology, pediatrics, and infectious diseases, for example, have designated medical specialty consultants, while the specialty of neurology has not. In the absence of a central supervisor, telemedicine requests may go unanswered until an AKO consultant becomes available. However, the CM ensures that all telemedicine requests are answered within a 24-h time period, regardless of the existence of a medical specialty consultant, by reminding the consultant group or individual providers to answer the consultation request.

The *AKO consultants* review and respond to consult requests every day of the week, including weekends and holidays. The first consultant to respond to the request assumes primary responsibility for the case until diagnosis and treatment recommendations are complete. If necessary, the primary responder may include other medical specialties to complete the request, but in most cases the consultants are board-certified experts in their fields.

Deployed providers generate the consultation requests and send them to the corresponding e-mail utility groups (see below), while adhering to local policies on the transmission and storage of patient information. The deployed provider also assumes primary responsibility for patient outcome and for reviewing the content of the consultant's recommendations. Once the case if closed, the deployed provider is also in charge of documenting the content and outcome of the teleconsultation in the patient's military medical record.

Store-and-Forward System Components

To facilitate the fast and efficient transfer of information between deployed providers and the appropriate AKO consultants, the store-and-forward system is organized into two components. The first component is a utility account with easy to remember e-mail addresses. The second component consists of a contact group which is populated with the e-mail addresses of specialty consultants. Only specialty consultants within a given utility account are able to view the requests and respond with a suggested diagnosis and treatment options.

Model Telemedicine Algorithm

In general, the deployed health-care provider generates one consultation request per patient in the form of a text narrative sent in an e-mail to the appropriate utility account. All e-mail accounts should have a common format: xxx.consult@XXXX.XXX. The

consultation request should include nonidentifying information about the patient (age, gender, occupation, branch of service, etc.), history of current injury/illness, previous treatments and outcomes (if applicable), laboratory test results (if any), the referring provider diagnosis, and limitations in managing the patient (e.g., availability of medications, procedures, and equipment). The deployed provider should also indicate his or her unclassified location in the consultation request in the event that the CM knows of any available regional medical assets or consultants. Any supporting digital images attached to the e-mail must obscure the face and any identifiable markings unless required for an accurate diagnosis. In compliance with HIPAA, no protected health information such as name, social security number, date of birth, medical record number, etc. should be included in the request. However, a consulting physician may request patient identifying information (PII) after initial contact is made so they can review the patient's medical history in the military health-care records system. If the consulting physician does not obtain the PII, he/she does not obtain workload credit for answering the teleconsultation.

After the e-mail is sent, the utility account automatically forwards the e-mail to a second server, called "contact groups," which has the names and e-mail addresses of the specialty consultants. The e-mail is automatically forwarded to the contact group, while the primary consultant retrieves the medical information and reviews the teleconsultation. Within 24 h of receipt, the primary responder replies to the entire specialty group and to the referring physician with diagnosis and treatment recommendations. The "reply to all" function ensures central visibility among the entire specialty group, thereby facilitating collaboration within the specialty (Fig. 1).

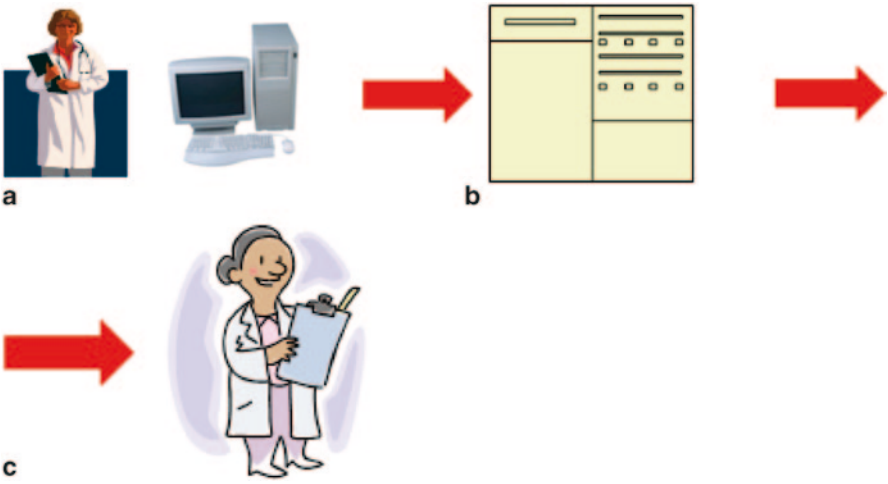


Fig. 1 Process of requesting telemedicine consultation. **a** The deployed health-care provider sends an e-mail to the utility account. All e-mail accounts have a common format: xxx.consult@XXXX.XXX. **b** The utility account automatically forwards the e-mail to a second server, called "contact groups," which has names and e-mail addresses of the consultants. **c** The e-mail is automatically forwarded to the consultants who answer the consultation. The consultant replies to the entire group and the referring physician. This facilitates collaboration within the specialty

The deployed provider may then respond to the group as a whole with follow-up questions or with new information that may change the consultant diagnosis. The CM may also send the consultation request with primary responder diagnosis to other specialties for further confirmation and collaboration. In 2011, approximately 15% of military neurology telemedicine cases involved such back-and-forth communication between the referring physician and consultants to achieve a final diagnosis and treatment regimen. In 2012, this number decreased to 9% of cases requiring such dialogue, indicating that referring physicians became more efficient at providing sufficient medical information for diagnosis and that the consultations were routed initially to the appropriate consultant groups.

Figures 2 and 3 provide case studies highlighting typical AKO teleconsultation e-mail exchanges. While one case involves occipital neuralgia and the other neurofibromatosis type 1, each of these cases follows the ideal algorithm with both deployed provider and consulting specialist utilizing the telemedicine program as intended.

Civilian Counterparts

There are a number of e-mail and web-based teleconsultation programs available in both the civilian and government systems. A health-care facility that is interested in a system can either purchase a commercial off-the shelf (COTS) system, task their information management directorate, or hire an outside agency to develop a system that meets their needs.

Take Home Points

The setup and operation of the AKO teleconsultation program allows for one or more specialists to provide medical opinions and also allows for rapid back-and-forth communication with the provider to obtain additional clinical details as needed. The overall goal of telemedicine use in theater is to deliver a timely assessment, to make an accurate diagnosis, and to deliver the appropriate medical treatment, all within strict confines of reliability and effectiveness so that the best patient outcome may be achieved.

Referring Physician's Narrative:
A 40-year-old white female who for the last 7 days has been complaining of (c/o) sharp "knife like" seldom pain onsets to the right occipital area, ~2 in posterior to the right ear. There were no MOI, no bug bites, no dizziness, no lightheadness, no vertigo, no weakness in either side of her body, and no noticeable facial/extremity palsy. Two years ago, she was "diagnosed with occipital neuralgia"; no record exists in her health record (H/R).

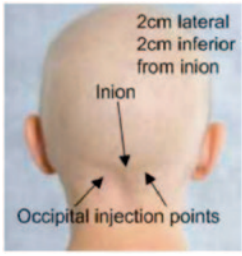
Now, she is experiencing these "quick and sudden" pain onsets that last less than 2 s. I put her on Indocine 25 mg (she is off it now and on Motrin 800 mg) and Robaxin 500 mg thinking that it may be some type of spasm in the temporalis or SCM muscles. She states that the medicines seemed to have taken the edge off the pain but, it still remains albeit, the pauses are longer now.

I was going to have her consulted by the officer-in-charge (OIC) at the XX Clinic (we were underway). We got there on the second and she was going to see him on the sixth but we got word to drop everything and get underway on the night of the fourth.

For what I have read, it would seem to be that [occipital neuralgia] again. There is no neuro deficit; CN I–XII are intact. No photophobia; strength and DTR are 3+ bilaterally. Neg Romberg.

Ophthalmologist's Reply:
This is out of the ophthal area. We shall monitor the message string though and provide input PRN.

First Neurologist's Recommendation/Diagnosis: I would agree that this history sounds very consistent with occipital neuralgia. The treatment of choice is an occipital nerve block. I use a mixture of lidocaine or bupivicaine and kenalog, and inject around the greater and lesser occipital nerves. Not sure if you have the capabilities to do such an injection there. It is a fairly simple procedure. I have attached some information about occipital nerve blocks but there are many resources on the Internet. An alternative would be to start a neuropathic pain agent such as neurontin 300 mg TID. This case sounds fairly straightforward and, based upon this history, would not require much more in the way of diagnostics.



Second Neurologists's Recommendation/Diagnosis: You are describing occipital neuralgia (ON). It is caused by entrapment of the C2—greater occipital nerve (sometimes the lesser). The usual treatment of choice is conservative therapy with heat packs and NSAIDS. If this does not work, you may consider greater occipital nerve block (GONB). I have attached a typical template note with the mixture I use. The procedure is very simple but would best be performed by someone familiar with it. I would have her seen at your next MTF to consider having the block tried. Also, muscle relaxants can sometimes help. I would use something like baclofen (probably not AMAL). It is less sedating and more effective than Flexeril. BOTOX has not been shown to be effective in the treatment of ON.

Diagnosis: Occipital Neuralgia

Outcome: Patient was injected at the region of maximal point tenderness (depth < 1 cm) with 2 ml of 0.5 % Ropivicaine and 5 mg of Triamcinolone (Kenalog-10mg/ml) solution. The patient was released with a scheduled follow-up.

Fig. 2 Teleconsultation example #1 (*c/o* complaining of, *dx* diagnosis, *DTR* deep tendon reflexes, *hx* history, *H/R* health record, *MOI* mechanism of injury, *MTF* military treatment facility, *NSAID* nonsteriodal anti-inflammatory drug, *OIC* officer in charge, *PRN pro re nata* [as needed], *SCM* sternocleidomastoid, *TID* three times a day)

Referring Physician's Narrative:
A 44-year-old white male has had soft nodules under his skin for the most part of his life. The nodules increased in numbers recently, and he was advised to be evaluated for neurofibromatosis. He is healthy with no past medical issues, no history of hypertension or back pain or other pain or numbness that may be explained by a neurofibroma. He has no surgical history. No medicines or allergies. He has no family members who have these nodules, but he does not know his father's side.
HEENT: Normal, with specifically no spots or nodules on his iris on slit lamp exam.
Skin: He has multiple soft nodules with a few on his chest and several on his back with only a few along his arms. They are compressible lesions and are softer than a lipoma. He has two larger areas of hyperpigmentation on his right side and otherwise no lesions that appear larger than 15 mm. He has axillary freckling and no groin freckling.
Additionally, he has no neurologic symptoms on my examination and appears well. In reviewing the diagnostic criteria for NF1, he does not have more than six café-au-lait spots. He does have more than two neurofibromas. He has axillary freckling, does not have Lisch nodules. He has no history of long bone problems and no family history. We are currently still off the coast, near a large naval medical center….

1. Is there enough of an increased risk for intracranial lesions to warrant sending him back for a full set of scans?
2. Does his later presentation mean he will likely have a milder course?
3. If sent ashore, is this neurology consult with dermatology evaluation or dermatology with neuro more appropriate?
4. Are there other conditions that would explain these findings and do these findings need to be evaluated now or can they wait until after deployment ~ 7 months?
Thank you again for this service and I look forward to whatever information you can provide.

First Neurologist's Recommendation/Diagnosis:
It is possible your patient has NF but without additional confirmation (histologic, radiographic) I am not completely convinced as the lesions are smaller than what I have seen in the several NF cases I have been involved with over the years. Also the absence of Lisch nodules (maybe sending a photo of the iris would be useful for us to review?), limited cutaneous signs other than nodules and lack of family history do not fit with classic NF. If he does indeed turn out to have NF, I would venture that because he is 44 and asymptomatic, this would predict a more benign course, but then again NFs are slow-growing lesions and could still cause major concerns depending on location/etc. Regarding evaluation, from the neurologic standpoint I feel he can safely hold on workup until you all return to home port, as you report he has no neurologic symptoms and has a normal neurologic examination. Regarding differential dx and other diagnostic recommendations for the skin nodules, I defer to my dermatology colleagues. Certainly if any change in examination is noted, especially if any objective neurologic signs develop during the rest of your deployment, he should be sent on for evaluation, but you and he should be OK for the remainder of your voyage.

Dermatologist's Follow-Up: Agree with Neurology that ultimately the diagnosis rests on histology (one or more biopsies) and imaging.
Could he have NF1? Yes
Does he have NF1? Maybe
Could he have segmental NF (this is a limited form)? Maybe

What else could he have? Collagenomas, leiomyomas, granular cell tumors, or any host of other benign soft tissue multiple neoplasms that occur in multiples.
Can he stay on the ship? Yes, but do realize that neurofibromatosis places you at an increased risk of meningioma, astrocytoma, glioma, and neurofibrosarcoma no matter what type he may have and about 5–10 % of lifetime risk malignancy.

Do you have the capability of snagging a punch biopsy or similar small biopsy of two representative lesions? If they were to confirm NF, I really would get him fully evaluated and he would need close lifetime specialty follow-up. Even if they come back as leiomyomas (although these are usually tender) that could mean he has Reed Syndrome (familial leiomyomatosis and renal cell carcinoma) and he would need kidneys checked for cancer. So much really rides on the actual pathology of the papular lesions.

These agminated (grouped) papules should be regarded as a cutaneous marker for something and I do favor it being NF and with a host of possible sequelae I would look at the big picture on this guy. If you think all of his papules fit into one dermatome, i.e., left-sided T10–12 (left chest, left back, left arm) then I would worry about him less because the segmental variety of NF does not have a whole lot of problems lifetime. If they are truly scattered all the heck over the place full phenotypic expression of NF is likely and he is at risk for malignancies as well as neurofibromas that can cause space occupying soft tissue problems.
So bottom line if you can get a biopsy cranked out that would settle the issue for me.

Referring Physician's First Follow-up: I will work on finding out the pathology of this patient. It was not in his chart when I looked previously, but I will use a few contacts to see if there are path results in AHLTA. Due to the size of the photos I was only abl e to send one or two because our ship is limiting the size of emails leaving the boat. He has lesions all over his body. Most are on his back, with some on his arms, chest and legs. So if he has it, then I am more concerned he has full NF. Thanks for the info. We have the capability of doing a punch biopsy and getting it ashore, but the command is currently planning on having him go ashore for further workup and if the workup is negative, he will meet us when we port.

Second Neurologist's Recommendation/Diagnosis:
Agree with all. Would add that only 50% of Nf1 is inherited, and the other 50% is spontaneous mutation (large gene, 17). Alth ough generally diagnosed early, also are NF1 modifier genes/factors (unidentified) that cause a variable presentation (spectrum/mosaics). See this periodically in recruits and young service members. 44 y/o is a new one for me, but certainly not unheard of in NF1 circles.

Fig. 3 Teleconsultation example #2 (*AHLTA* Armed Forces Health Longitudinal Technology Application, *dx* diagnosis, *NF1* neurofibromatosis type 1, *y/o* years old)

Referring Physician's Second Follow-up: Thanks for the info. I was able to contact a friend ashore and get biopsy and pathology results which were not in the patients chart. He did have 3 biopsies in June which were positive for neurofibromas. The patient had three lesions which were benign neural tissue, later stated to be neurofibromas. The patient does have larger lesions in a different area on his chest and on his arms.

I appreciate the help and discussion that this service has provided and I have to say that I have learned a lot through this whole experience.

Diagnosis: NF1

Outcome: Patient sent to Naval Medical Center San Diego to see neurology and to direct his care and follow up.

Fig. 3 (continued)

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