Total-Body Photography in Skin Cancer Screening: The Clinical Utility of Standardized Imaging

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PRACTICE **POINTS**

- Advances in technology have the potential to provide affordable standardized total-body photography platforms.
- Total-body photography augments the clinical examination and plays a role in clinical decision-making.
- Total-body photography has the potential to become a part of the total-body skin examination and increase access to dermatologic care.

Early detection of skin cancer is essential to reducing morbidity and mortality from both melanoma and nonmelanoma skin cancers. Total-body skin examinations (TBSEs) may improve early detection of malignant melanomas (MMs) but are controversial due to the poor quality of data available to establish a mortality benefit from skin cancer screening. Total-body photography (TBP) promises to provide a way forward by lowering the costs of dermatologic screening while simultaneously leveraging technology to increase patient access to dermatologic care. Standardized TBP also offers the ability for dermatologists to work synergistically with modern computer technology involving algorithms capable of analyzing high-quality images to flag concerning lesions that may require closer evaluation. On a population level, inexpensive TBP has the potential to increase access to skin cancer screening and it has several specific applications in a military population. The utility of standardized TBP is reviewed in the context of skin cancer screening and teledermatology.

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Skin cancer is an important public health issue in the United States, as 1 in 5 Americans are projected to develop a cutaneous malignancy during their lifetime. Currently, 75% of all skin cancer–related deaths are due to malignant melanomas (MMs), though melanomas account for less than 5% of all skin cancers.[1] Early detection of MM is essential, as prognosis depends on tumor stage, particularly the depth of the melanoma.[2-4] In general, patients with thin, early-stage melanomas have a more than 96% survival rate, which drops to 14% in late-stage disease.[5,6] Five percent to 30% of all melanomas are identified incidentally on total-body skin examinations (TBSEs) performed by a trained provider and thus would not have been caught with only a focused skin examination or patient self-examination.[7,8] Nonetheless, the clinical utility of skin cancer screening with TBSEs remains

controversial, largely due to the poor quality of data available to establish a notable mortality benefit from skin cancer screening. As a result, obtaining endorsement from the larger medical community, federal government, and health insurance industry to include routine TBSEs as part of a preventive care health care strategy has not occurred. The absence of definitive clinical care guidelines mandating routine TBSEs is one of the greatest barriers preventing access to appropriate dermatologic screening along with the paucity of trained providers; however, standardized total-body photography (TBP) promises to provide a way forward by lowering the costs of dermatologic screening while simultaneously leveraging technology to increase availability.

Impact on Biopsy Efficiency

Current US Preventive Services Task Force (USPSTF) guidelines state that evidence is insufficient to assess the balance of benefits and harms of visual skin examination by a clinician to screen for skin cancer in adults. The USPSTF noted that "[d]irect evidence on the effectiveness of screening in reducing melanoma morbidity and mortality is limited to a single fair-quality ecologic study with important methodological limitations" (ie, the Skin Cancer Research to Provide Evidence for Effectiveness of Screening in Northern Germany [SCREEN] study), and although information on harm is similarly sparse, "[t]he potential for harm clearly exists, including a high rate of unnecessary biopsies, possibly resulting in cosmetic or, more rarely, functional adverse effects, and the risk of overdiagnosis and overtreatment."[9] The majority of suspicious skin lesions excised during screenings are not cancerous. For example, the SCREEN study found that 20 to 55 excisions were performed to detect 1 case of melanoma.[10] At that rate, the USPSTF also noted that approximately 4000 excisions would be required to prevent a single death from melanoma.[9] Following the lead of the USPSTF, the Patient Protection and Affordable Care Act did not mandate that skin examinations be included as essential preventive coverage in its requirements for insurance coverage of primary care prevention. As such, dermatologists face financial pressure to avoid performing time-consuming TBSEs, regardless of their perceived utility.[11]

As the USPSTF points out, the value of TBSEs relies on the examiner's ability to correctly identify malignant lesions and minimize biopsies of benign lesions, a concept known as biopsy efficiency.[9] Secondarily, a TBSE is time consuming, and the time required for a dermatologist to complete a TBSE given the high rate of benign findings may not be financially viable. We argue that the routine use of total-body skin imaging may offer a way forward in addressing these issues. Total-body photography involves a photographic system that can allow dermatologists to acquire standardized images that can be used for primary diagnosis and to track individual lesions over time. Nonmedical personnel and medical assistants can be easily trained to use standardized photography devices to quickly obtain high-quality clinical images, thereby greatly reducing the time and cost of obtaining these images. Studies have found that the use of photographic monitoring may improve biopsy efficiency.[12-15] A recent study by Truong et al[16] found that TBP used to monitor all existing melanocytic lesions on patients substantially reduced the number of biopsies that patients required. These results reflect that most nevi, including clinically atypical nevi, are usually stable and unlikely to exhibit suspicious changes over time.[17,18] For this reason, the use of TBP could minimize unnecessary biopsies because clinically suspicious but stable nevi can be objectively documented and followed over time.

Standardized TBP also offers the ability for dermatologists to work synergistically with modern computer technology involving algorithms capable of analyzing high-quality images to autodiagnose or flag concerning lesions that may require biopsy. Esteva et al[19] described their development of a deep learning algorithm that relies on a convolutional neural network (CNN). This CNN was trained to identify melanomas using a large data set of clinical dermatologic images and subsequently was able to distinguish MMs from benign nevi at a rate on par with a board-certified dermatologist.[19] Widespread use of total-body imaging would create an enormous database of high-resolution images that would be ideally suited to the development of such computerized algorithms, which could then be applied to future images by way of artificial intelligence. Convolutional neural networks that use a single patient's imaging over time could be developed to assess the change in number or size of benign nevi and identify lesions that are concerning for MM while simultaneously comparing them to a population-based data set.

On a large scale, such a capability would minimize the inefficiency and subjectivity of TBSEs as a tool for identifying malignancy. Currently, dermatologists are only able to track and document a few concerning lesions on a patient's body, rendering the choice of which lesions require biopsy more subjective. Total-body photography, particularly if used with an algorithm capable of quickly analyzing all the nevi on a person's body, largely eliminates

such subjectivity by creating a standardized set of images that can be tracked over time and flagging concerning lesions prior to the dermatologist examining the patient. In this way, the specialty of dermatology could achieve the same model of objective evaluation of standardized clinical images as those employed in radiology, cardiology, and other clinical disciplines. The additional benefit of such a system would be lower costs, as the images could be acquired by nonmedical personnel and then undergo initial assessment by an algorithm, which would flag concerning lesions, similar to a modern electrocardiogram machine, allowing the dermatologist to use his/her time more efficiently by only focusing on concerning lesions with the confidence that the patient's entire body has already been rigorously screened.

By using TBP to improve biopsy efficiency and the objectivity of the TBSE as a tool to detect skin cancer, we propose that the benefit-to-harm ratio of the TBSE would remarkably improve. Ultimately, this type of screening would meet the strict requirements to be included in preventive health care strategies and thereby improve access to dermatologic care.

The Use of TBP in the Military

Total-body photography has several specific applications in the military. Standardized imaging has the potential to improve dermatologic care for active-duty soldiers across space and time. First, a large percentage of deployment medical care is devoted to dermatologic issues. From 2008 to 2015, 5% of all medical encounters in the combat theaters of Iraq and Afghanistan involved dermatologic concerns.[20] Access to appropriate dermatologic care in a combat theater is important, as poorly controlled dermatologic conditions (eg, psoriasis, eczema) often require evacuation when left untreated. Although current TBP systems may not be portable or durable enough to survive in an austere deployment environment, we propose it would be feasible to have skin imaging booths at larger forward operating bases. The images could then be transported to a remote dermatologist to assess and recommend treatment. The expense of transporting and maintaining the imaging system in country would be offset by the expenses spared by not requiring a dermatologist in country and the reductions in costly medical evacuations from theater.

Although the US military population is younger and generally healthier than the general adult population due to extensive medical screening on admission, age limitations for active-duty service, a mandated active lifestyle, and access to good health care, there are still a substantial number of service members diagnosed with skin cancer each year.[21] From 2005 through 2014, MM was the most common non–gender-specific cancer (n=1571); in men, only testicular cancer was more prevalent (1591 vs 1298 cases), and in women, only breast cancer was more prevalent (773 vs 273 cases). Furthermore, from 2004 to 2013, the incidence rates of melanoma have increased by 1.4%, while with other cancer rates have declined during the same time period.[21] Thus, TBP as a screening modality across the military population is a promising method for improving detection of skin cancer and reducing morbidity and mortality.

Military medicine often is on the forefront of medical advances in technology, disease understanding, and clinical care due to the unique resources available in the military health care system, which allow investigators the ability to obtain vast amounts of epidemiologic data.[22] The military health care system also is unique in its ability to mandate that its members obtain preventive health services. Thus, it would be possible for the military to mandate TBP at accession and retirement, for instance, or more frequently for annual screening. The implementation of such a program would improve the health of the military population and be a public health service by pioneering the use of a standardized TBP system across a large health care system to improve skin cancer detection.

Current Studies in the Military

The Dermatology Service at the Walter Reed National Military Medical Center (WRNMMC) (Bethesda, Maryland) is evaluating the use of a total-body digital skin imaging system under a grant from the Telemedicine and Advanced Technology Research Center of the US Army. The system in use was found to be particularly well suited for military dermatology because it offers standardized TBP processing, produces a report that can be uploaded to the US Department of Defense (DoD) electronic medical record system, and requires relatively brief training for ancillary personnel to operate. Regardless of the platform the DoD ultimately finds most suitable, it is critical that a standard exist for TBP to ensure that uniform data sets are generated to allow military and other DoD dermatologists as well as civilian health care providers to share clinical information. The goal of the current study at WRNMMC is to vet TBP platforms at WRNMMC so the military can then develop standards to procure additional platforms for placement throughout the Military Health System, Military Entrance Processing Stations, operational environments, and

collaborating health care systems (eg, the Veterans Health Administration).

Once deployed broadly across the Military Health System, these TBP platforms would be part of a network of telehealth care. For acute dermatologic issues, diagnoses provided via teledermatology platforms can then be managed by health care providers utilizing appropriate clinical practice guidelines or by non–health care providers utilizing general medical knowledge databases. Such a system with TBP information collected at multiple access points across a service member's career would build a repository of data that would be immensely useful to patients and to clinical research. Of particular interest to military researchers is that TBP data could be used to study which patients require in-person examinations or more careful monitoring; the proper intervals for skin cancer screening; and the assessment of the benefits of TBP in improving morbidity, mortality, and biopsy efficiency in the detection of MM as well as nonmelanoma skin cancers.

Limitations to Progress

Currently, there are multiple limitations to the implementation of TBP as a part of TBSE screening. First, the potential improvement in biopsy efficiency using TBP is predicated on its ability to prove nevi stability over time, but in younger populations, benign nevi are more likely to change or increase in number, which may reduce the biopsy efficiency of screening in a younger population, thereby negating some of the benefit of imaging and CNN assessment. For instance, Truong et al[16] found that younger age (<30 years) did not show the same improvement in biopsy efficiency with the use of TBP, which the authors theorized may reflect "the dynamic nature of nevi in younger patients" that has been documented in other studies.[23,24] Approximately 65% of the active-duty military population is aged 18 to 30 years, and 98% of accessions to active duty occur in individuals aged 17 to 30 years.[25] As such, TBP may not improve biopsy efficiency in the active-duty military population as dramatically as it would across the general population.

A second limitation of the use of TBP in the active-duty military population is the ethics of implementing DoD-wide mandatory TBP. Although the TBP platform will be compliant with the Health Insurance Portability and Accountability Act, mandating that soldiers contribute their TBP to a repository of data that will then be used for research without explicitly requesting their consent is ethically problematic; however, since the 1950s, the DoD has collected serum samples from its service members for force protection and operations reasons as well as for the purpose of research.[22,26] Currently, the DoD Serum Repository collects serum samples as part of a mandatory human immunodeficiency virus screening program that evaluates service members every 2 years; this repository of human serum samples is accessible for research purposes without the consent of the individuals being studied.[27] These individuals are not informed of potential use of their serum specimens for research purposes and no consent forms or opt-out options are provided. Thus, although there is precedent in the DoD for such mass data collection, it is an ongoing ethical consideration.[28]

Finally, although the potential use of TBP and computer algorithms to improve the efficiency and affordability of TBSEs is exciting, there are no existing computer algorithms that we are aware of that can be used with existing TBP platforms in the manner we proposed. However, we feel that computer algorithms, such as the one created by Esteva et al,[19] are just the beginning and that the use of artificial intelligence is not far off. Even after the creation of a TBP-compatible algorithm adept at analyzing malignant lesions, however, this technology would need to be further evaluated in the clinical setting to determine its capability and practicality. Current TBP platforms also are limited by their large size, cost, and complexity. As TBP platforms improve, it is likely that more streamlined and less expensive versions of current models will greatly enhance the field of teledermatology, particularly in the military setting.

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