

Guidelines for Point of Care Medical Thermography

General Statement:

This Guideline, developed by American Academy Of Thermology (AAT) members, outlines best-practice instructions for the practitioner in recording skin temperature abnormalities for medical use outside the controlled laboratory. This Guideline implies a consensus of those substantially concerned with its scope and provisions. Individuals or groups wanting to reaffirm, modify, or revoke this Guideline must submit proposals within three years of publication, per the Procedures of the AAT. The Executive Director of the American Academy of Thermology welcomes suggestions for improvement. No part of this Guideline may be reproduced in any form, in an electronic retrieval system, or otherwise, without the publisher's prior written permission.

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Statement Of Need

Thermography has grown significantly since its initial medical applications in the 1950s. As in all of medicine, technological advancements drive change. Smaller, more portable infrared imaging devices with enhanced image quality and user-friendly interfaces enabled widespread and effective use of thermography by healthcare professionals. Today, this use includes point-of-care (POC) applications.

Measuring skin temperature aberrations (deviations or abnormalities in the skin temperature from the expected or baseline levels) provides essential insight into physiologic manifestations of potential injury or disease processes.

Infrared Thermal Imaging is the only noninvasive, noncontact technology, with no-ionizing radiation available that images and maps microcirculatory shunting (vasomotor instability) associated with many disorders. There are numerous applications where infrared imaging can aid, define, or rule out a diagnosis and help direct appropriate treatment. Using thermography can be instrumental in understanding the pathophysiology of conditions and improve patient outcomes.

Early adopters of medical thermography, recognized the value of using infrared imaging in clinical settings. These practitioners have dedicated significant effort to validating thermography's safe and effective use in daily physical health assessment, thus establishing it as a distinct and valuable tool within the broader field of infrared imaging.

In studies and practical use, practitioners have proven clinical thermography to be a safe, quick, and cost-effective adjunct that enhances patient care. Thermography can aid in diagnoses of various conditions, guide invasive procedures safely, supplement treatments, and monitor the progression of interventions or changes in a patient's condition.

The integration of infrared thermal imaging in POC applications promises to be an exciting advancement. The American Academy of Thermology ardently supports this integration. With the increasing ubiquity of clinical thermography across the healthcare landscape and multiple practice settings, the AAT has recognized the need to clearly outline Point of Care Guidelines for Thermography.

The AAT recognizes the need for continuing medical education supporting the science and methodology of thermal imaging in these new applications. It is committed to documenting and correlating the temperatures and diverse heat patterns derived from POC imaging in both normal and abnormal conditions as extensions to its current clinical library. This documentation supports the pivotal role thermography can play.

Traditional Guidelines advocate the performance of medical infrared imaging in temperature-controlled laboratory settings, patient equilibration periods prior to imaging, and a field of view that allows the region of interest to fill seventy five percent (75%) of any selected image acquired at a specified distance. POC studies do not, however, have to meet these standards. While several other important factors also differentiate medical thermology from POC clinical applications, the AAT recognizes that POC imaging can provide valuable information not seen in controlled labs.

POC imaging does not replace controlled laboratory studies but can help assess unknown underlying conditions often missed in daily physical assessments. Conducting infrared imaging in a POC setting requires knowing what specific data parameters highlight 'abnormal' changes and that these may vary depending upon the condition under study.

While the AAT has actively participated in the establishment of normal temperature values for medical thermology, much work remains to be done when it comes to POC studies. Clinicians are encouraged to work with the AAT to establish "best practice" principles in collecting and interpreting thermal data in each evaluation. Practitioners must have a thorough understanding of environmental variables that influence thermal data, as well as medical knowledge of known physiological contributors that altered circulatory patterns.

This document aims to provide clear and unified guidelines for practitioners conducting POC thermography. It emphasizes the importance of competency-based training, education, and proficiency standards, which are crucial for enhancing clinicians' use of thermography and ensuring its safe and practical application in various areas of clinical practice.

This text is for those interested in incorporating POC Thermography into their practice, especially in areas needing more specific specialty definition. Adhering to peer reviewed guidelines is vital to ensure that POC Thermography is used appropriately by clinicians, ultimately benefiting patients who can gain from its use.

Definition and Scope of Point-of-Care Thermography

Point-of-care thermography (POCT) is a focused thermographic examination conducted and interpreted by the treating clinician at the point of care. It addresses a specific clinical question or can guide a medical procedure. POCT is an adjunctive diagnostic tool that provides clinically significant data not easily obtainable through visual inspection, palpation, auscultation, or other traditional physical examination components. Furthermore, it should be considered a complementary addition to these methods. It offers an extra dimension of functional and physiological information that enhances patient care.

For this Guideline, POCT will be used synonymously with terms such as "bedside," "focused," and "point-of-care imaging". Over time, specific applications of POCT may require further definition for various applications such as emergency, intraoperatively, and domestic violence.

POCT is goal-oriented and focused, with the primary aim of swiftly addressing critical clinical questions about specific organ systems or evaluating clinical symptoms and signs. POCT can be used as a single examination or repeated as necessary due to changes in clinical conditions. POCT can monitor physiological or pathological changes and assess response to treatments.

The distinctive advantage of POCT is the real time performance, interpretation, and integration of findings into a paradigm of care by the evaluating clinician, with the patient present. The immediate visualization of the physiological state and associated pathology significantly enhances the safety of clinical evaluations and procedures that otherwise would traditionally be conducted without imaging.

Suggested Applications of Point of Care Thermography in Medical Practice:

Note: In all of the described applications POCT can be used for both the early detection and progression of the disease and response monitoring

Tissue Injury and Compromise Evaluation:

Real-time infrared thermography for evaluating tissue perfusion during surgeries

Post-operative follow-ups for interventions such as sympathetic blocks, sympathectomies, nerve stimulator placements, and tissue graft efficacy.

Assessment of pressure injuries related to conditions such as diabetes, neuropathies, or bedridden patients.

Evaluation of compartment syndrome and other difficult to diagnose musculoskeletal condition

Analysis of injuries from sports, exercise, or physical contact

Documentation of strangulation, strangulation attempts, and domestic or other physical violence

Locating, Identifying and management of venomous animal bites and stings.

Neuro-musculoskeletal (INMSK) Analysis

Assessment of acute, exacerbating, or complex, chronic musculoskeletal pain conditions.

Evaluation of NMSK conditions with dysautonomic components

Investigation of dysautonomias

Exploring chronic migraine or mixed headaches

Identification of neurovascular conditions such as thoracic outlet syndrome

Assessment of failed neck, back or limb surgeries (persistent pain remains a primary complaint).

Vascular Health and Circulatory System Analysis:

Pre-procedure assessment of interventional therapies and surgeries

Assessments for vascular disorders

Identifying patterns of vascular compromise (vascular mapping) and to aid in treatment plan creation for conditions including, but not limited to, varicosities, peripheral edema, venous thrombosis, AV fistulas, and certain cerebral vascular disorders.

Oncological Conditions Analysis:

Breast thermal findings assessment

Thyroid conditions

Surface skin conditions

Tracking subdermal vascular spread in conditions such as melanomas and sarcomas.

Other Clinical Applications:

Investigating occupational diseases in industrial work environments.

Fever identification during medical consultations, including potential COVID-19 detection.

Dermatological analysis complementing dermoscopy.

Tracking disease improvement, progression, or spread for skin infections or inflammation.

Evaluating inflammatory responses and post-operative or post-fracture pain.

Ophthalmological use for orbit disorders or for detection of obstructions in the lower lacrimal system.

Assessment of dental infection or inflammation

Monitoring Acupuncture and restorative modality effects

Assessment of conditions where skin temperature aberrations may exist.

Specialized Veterinary Medical Applications:

It is important to note that circulatory and tissue injuries can occur in all species. Veterinary use of Infrared Imaging includes evaluation of equine, bovine, ovines, caprines, canine, feline, cetaceans, exotics, and aquatics. Infrared imaging allows visual extension of the physical exam in natural habitats and point-of-care settings. Infrared imaging can demonstrate evidence of disease or injury by recording circulatory and temperature changes that otherwise might not be known or adequately assessed. Species-specific temperature values are recorded for herd animals and most exotics and can aid in assessments of tissue perfusion.

Veterinary applications include but are not limited to:

Musculoskeletal strain and overuse injuries

Lameness evaluations, investigations of the origin of gait abnormalities,

Evaluate the impact of exercise, training, stress testing and endurance injuries

Visualization of potential illegal or proper applications of injections and medications

Assessments for soring, saddle fit, abscess, laminitis, shoeing abnormalities, mud fever,

Monitoring of the effectiveness of restorative therapies, nerve blocks or other treatments.

Contraindications and Limitations:

In POC applications, any absolute contraindications encompass scenarios where obtaining accurate thermography readings or necessary images is impeded. Relative contraindications include an uncooperative patient or individual with pre-existing conditions that hinder the exam.

The patient (or guardian) must consent to capturing and use of infrared images. While informed consent is a cornerstone of medical ethics and patient rights, its application can differ depending on context in the POC thermography practice. The requirements for formal informed consent may vary based on several factors:

- Subjects should be told that POC imaging is a noncontact, noninvasive, no radiation, imaging technique and significantly reduces potential risks.
- Detailed written consent may be impractical however in urgent care and emergency settings where immediate decision-making and rapid diagnosis and treatment is mandated.
- Written or verbal consent in clinical practice and outpatient settings is more likely than not appropriate, however such a determination must be by the treating provider. The clinician typically explains the purpose and nature of thermography before proceeding with an assessment.

- During a physical examination thermography may become part of the routine process, especially in specific medical conditions requiring regular monitoring of skin temperature. In cases such as these POC thermography is an extension of the physical exam and consent may be implied as part of the patient's general agreement to undergo medical evaluation (local and Federal regulations should be considered).

Infrared Imaging Equipment

Infrared imaging measures and maps the degree and distribution of IR thermal emission from the body. When studies are performed according to guidelines, asymmetric or localized IR emission with variations of 1°C are usually considered to be outside the range of accepted normal values; however, in specific applications, aberrations can be less or greater than 1 degree. Each application considers regional norms.

Infrared imaging equipment should meet standards whether used in a formal medical thermology lab or as POC Imaging. Specific requirements are necessary to produce quality infrared images. The technical aspects of infrared imaging equipment, understanding the environment and possible influencing variables, and the patient's physiology need to be considered.

Minimum equipment specifications

To prove that a thermal camera uses an accepted calibration protocol, a manufacturer should be able to provide evidence of Certification from a recognized organization (like ISO or IEC) proving that the camera meets international standards for calibration. Calibration to a known temperature standard may be necessary. Standard calibration protocols typically reference a black body radiator at known temperatures, however specifics can vary. OEM's should detail the procedures used, the results obtained, and the calibration date for its certificates.

The calibration process should cover the operational temperature range of the camera. The range relevant for human body temperature detection is approximately 20-40 degrees Celsius. The calibration accuracy should meet the required standards for medical diagnostics, usually within a small margin of error ($\pm 0.1^\circ\text{C}$ or better).

The internal temperature of thermal imagers can drift over time so regular internal re-calibration is necessary to maintain accuracy. The frequency of re-calibration depends on the manufacturer's recommendations and usage intensity. Thermal drift is caused by internal heating of equipment during regular operation, or by changes in external ambient temperature. Preferably, the imager should not auto-calibrate during an exam. This will distort the exam data.

Emissivity settings should be readily accessible. Emissivity is typically set to that of human skin, typically around 0.98. Certain areas of the human body such as the eyes, mouth, and thin skin of newborn children, have different characteristics however. Emissivity values other than 0.98 may be necessary for accurate thermal readings in these cases.

Eyes: as thin skin and the presence of mucous membranes can affect emissivity areas around the eyes, a lower emissivity value, such as 0.95, may be more appropriate,

Mouth: For the mouth region, where there are also mucous membranes and thin skin, an emissivity value of around 0.94 to 0.96 may be more appropriate.

Neonate Children: Considering differences in skin composition for the thin skin of newborns and neonates slightly lower emissivity values of 0.92 to 0.95 have been suggested.

The lens field of view (FOV) for medical thermology studies typically ranges from 42 to 54 degrees, with the patient-to-imager distance set at approximately 3 feet (it is adjusted as needed to ensure that the region of interest fills approximately 75% of the image). Imagers for POCT may need to employ a lens FOV ranging from 42 to 54 degrees, as the distance between the detector and the subject under study is typically shorter than 3 feet.

Imager detector spectral bandwidth of 8 to 14 microns (micrometers).

Strict control over thermal drift and maintenance of detector uniformity are essential ($V < 0.2\text{m/s}$). The camera should consistently produce the same results under the same conditions, indicating reliability and repeatability in its measurements.

Thermal sensitivity of greater than 50mK Noise Equivalent Temperature Difference (NETD) to detect subtle temperature differences is required. NETD represents the smallest temperature difference that a thermal imaging system can reliably detect.

Systems should render images in hi-resolution color, grayscale, and inverted grayscale thermal scales.

Video mode applications require high frame rates, and real-time image capabilities including image focus and image capture.

Image Acquisition

Regardless of the setting the patient/representative should be educated on the need for POC Thermography.

Specific actions to ensure good imaging are necessary.

- Skin must be exposed. Skin exposure for an approximate amount of time aids in dissipating heat caused by contact with clothing or coverings like blankets and sheets.
- Position patients to reduce pressure in the area of concern, allowing for skin temperature acclimation before image capture. Using infrared imaging to detect nonvisible pressure injuries, such as suspected pressure ulcer development, requires offloading or repositioning to evaluate any area of the bony prominence.
- No external infrared influence should be present. Block sunlight, cover any reflective surfaces, and eliminate or control physical contact.
- Place supporting devices used to reposition the bedridden away from the body area being evaluated (legs supported but heels floating for evaluation of heel pressure ulcers; side-lying positions to acclimate and image the coccyx, spine, and scapular pressure points, occipital and ear points). Most pressure points occur on dependent or posterior areas; any anterior areas of concern, i.e., patella, elbows, and dorsal feet, should be imaged prior to position change. Contralateral image capture is encouraged as it allows for temperature comparison.
- Evaluation of Extremities: When possible, both limbs should be included within the same image even if a dual injury is suspected. Image both hands, arms, legs, and all surfaces for comparison during evaluation. Concave and convex contours will emit infrared differently, and direct images (lens perpendicular to body surface) are necessary. Capturing separate images of contralateral regions (each

hand or limb separately) may lead to temperature variance due to drift, position, or capture angle. Additionally, the patient limb should not be in contact with any object during imaging.

- Patients requiring lower limb circulation evaluation should stand, when possible, as seated positioning can impede blood flow. Ensure the patient has even weight distribution to both limbs. Assistive equipment should not obstruct image acquisition. Recommended AAT and AIIR Alliance-approved postures are on the AAT website.
- Appropriate privacy is maintained for human imaging regardless of the environment.
- The skin is as clean as possible. Note any variables (including abrasions with dirt, debris, and scabbing). Remove moisture on the skin without pressure. Avoid applying ointments as they will alter results. POC thermography may preclude this. Whenever possible, instruct the patient to avoid placing any material of any kind on the skin, such as any skin lotions, sunscreens, deodorants, preparations, moisturizers, salves, makeup, hair spray, hair cream, topical analgesics, patches, the day of the exam.
- Avoid other medical testing or procedures on the same day prior to thermal imaging, preferably for 24 hours before a thermal exam - especially if studies can impact skin temperature.
- Record the type of equipment used during imaging and the duration of study in the examination record. Equipment varies significantly with the POC applications.
- Images obtained during physical activities should have any contributing variables recorded and contralateral images obtained for best evaluation. Imaging devices with infrared and photographic capabilities aid in more accurate injury evaluations. HIPAA compliance must be maintained with any photographic images, and time and sequence should match the time stamp on the comparative infrared image. Most imaging devices with dual capacity will record concurrent images.
- Infrared evaluation may not reveal the anticipated result. 'Thinking thermally' often needs to be more intuitive. Therefore, history and physical information can contribute to the analysis. Obtain a complete, pertinent history by interviewing and/or reviewing the patient's medical record when possible.
- When applicable, a pertinent history includes the following: Current medical status, especially regarding pain and vasomotor instability and presenting complaints or circumstances. Note the presence of any signs or symptoms associated with autonomic dysfunction. A symptom/ injury diagram should be completed (i.e., pain, numbness, tingling, fracture, contusion, etc.). Remember that imaging conducted in a stressful setting (i.e., injury or recent violence, should be conducted as soon as possible, and all other information should be gathered post-imaging when possible. Circulatory patterns will change over time with the degree of tissue damage. Assess and approximate time from injury.
- Patient medications that can alter circulation should be included in the history. These include but are not limited to anti-hypertensive, anti-depressants and anti-anxiety medications, any hormones, and anti-spasmodic and anti-seizure medications. Include supplemental, herbal, and oriental medicines when possible, as many affect circulation and hormones.

Best Practices for Image Capture

Current best practices suggest capturing at least one skin surface image in each orthogonal plane of each relevant structure. In POCT, capturing comprehensive images from multiple angles or perspectives of the area of interest is recommended to provide a thorough visual representation of the findings.

In summary, meticulous image capture and labeling are integral components of POCT. These practices enhance the quality of patient records, ensure compliance with medical documentation standards, and facilitate future reviews or audits of the imaging performed.

Labeling and Recording of Images

For POCT examinations the technician should label the orienting anatomy. Patient safety is paramount. Carefully position the patient to get a clear view of the area of concern.

Images must be permanently recorded and maintained in the patient's record. This practice ensures that future patient medical history reviews include comprehensive visual documentation of the thermography findings.

Storage and Accessibility of Images

Thermal images must be available for review upon request. The images can be stored as printed copies or in a digital format, ensuring they are accessible for future reference or audits.

The Thermographic Report

Medical infrared evaluation should adhere to accepted reporting criteria. Thermographic reports follow similar formatting to other medical reports, such as used by radiologists. The report is based on quantitative data, metrics, asymmetries, and objective results, allowing for comparison with the contralateral limb or the same subject over time. Subjective comments should be avoided.

The interpretive report should address Thermal Findings as a separately identifiable section within the body of the report. Thermographic Impressions and Clinical Impressions are not part of the Thermographic Findings. Each is a separate section.

Clinical Impressions are medical opinions. Statements in this section of the report include differential diagnosis and recommendations for further diagnostic assessment or treatment. The interpreting thermologist should not provide Clinical Impressions unless he/she has performed a history and physical examination of that patient. Treatment recommendations should not be formulated based on thermal imaging alone. Thermal imaging may clarify the diagnosis, and recommendations may include further studies to assess the diagnosis more accurately. Practitioners who have direct patient contact can make treatment recommendations. Off-site consulting thermologists do not make treatment recommendations.

Medical Necessity

As with ultrasounds, POCT examinations must have a documented medical necessity. Documentation includes a written order from the provider and if filed with insurance, it must meet the requirements for completeness as per the specific Current Procedural Terminology (CPT) code billed. Documentation ensures that each thermography session is justified, relevant, and follows coding and billing guidelines.

Written Interpretation

The findings from POCT exams should be interpreted in a timely manner and communicated to providers, consultants, and other patient care team members through a separate written report. This report must be maintained in the patient's medical record and should include:

Date and time of the examination.

Patient's name, hospital or clinic identification number, age, date of birth, and sex.

Name of the clinician who performed and/or interpreted the study, along with clinical findings.

Indication for the study, whether the scope is complete or limited, details on if it is a repeat study, and the level of service.

Impressions, including non-diagnostic studies, differential diagnoses, the need for follow-up exams, and any incidental findings. (These are not included in "Thermal Findings")

The mode of archiving the data, specifying where the images can be viewed.

Report Management

Efficient management of the reports (whether handwritten, transcribed, templated, or computerized) and their timely addition to the medical record is crucial. It facilitates communication within the healthcare team, improves patient management, and is vital for peer review and quality assurance processes.

Documentation for Guided Procedures

In cases where POCT is used to guide procedures, the procedure report may be filed separately in the patient's record or included within the report of the primary procedure. This documentation is essential for maintaining a comprehensive record of the patient's care and the specific use of POCT in their treatment.

In conclusion, rigorous documentation is essential in the practice of POCT. It ensures that each procedure is medically necessary, appropriately communicated, and accurately recorded, thereby maintaining high standards of patient care and compliance with medical and legal requirements.

Storage of Exam Findings

Images should be taken and saved in radiometric file format at the highest resolution possible to help assure the best possible focus and adequate vascular pattern analysis. All radiometric images should have the capability to be converted to standard digital image formats to assist in record-keeping and interpretative report preparation. Formats, such as JPEG, TIF, or PNG, can be used for export however it is preferred to at least have the option to do so in DICOM. Some manufacturers preserve radiometric information in their JPEG exports.

Integration with EHRs requires standardized data formats, like DICOM, and adherence to interoperability protocols. Integration will vary widely across different healthcare systems. Integration should, however, incorporate secure and efficient data transfer mechanisms. Adherence to relevant healthcare data privacy regulations (HIPAA in the US) ensures that the thermal imaging data is seamlessly accessible within the EHR system for analysis and reference by healthcare professionals. Integration should support metadata inclusion, such as patient information, exam details, and specific annotations made by imaging specialists, to provide comprehensive content for each set of thermal images.

Continuing Professional Education Interpreting Thermologist certification:

The person performing the analysis/reporting of a medical thermology study should be a member in good standing of a nationally recognized medical thermographic organization that offers literature, training, and support specific to medical infrared imaging and should maintain appropriate certification from that organization.

Technologist certification is considered the standard of practice for image acquisition, and infrared imaging is no different. It indicates an individual's competence to perform infrared studies at the entry-level. Supervising physicians should keep current on advances in diagnosis and treatment of their respective specialty, thermal imaging equipment, imaging techniques, new interpretation and reporting software, and published studies on thermal imaging. They should, at a minimum, be a member in good standing of a nationally recognized medical infrared imaging organization that offers up-to-date practice guidelines and training

All Thermologists are expected to keep current with advances in diagnosing and treating conditions requiring specific Point of Care image sets and related physiological information if they offer interpretation services to a particular sector. They should be aware of changes in infrared and examination protocols or published diagnostic criteria and advances in infrared and other evaluation technology used for the examinations.

Emerging Technologies:

Technology that can challenge existing guidelines or that does not necessarily conform to currently accepted practices is constantly being introduced. These technologies can span the entire spectrum of sophistication and require different adaptive responses.

Today, systems with visual image technological enhancements can provide accurate limited ROI thermal readings. Because POCT typically is done at a distance of less than three feet, such devices may be applicable for these measurements. At a distance greater than three feet, however, imaging is no longer considered POCT and said devices are likely no longer satisfactory.

Advances in artificial intelligence (AI) may be used in image evaluation. Many new imaging devices and software utilizing AI must provide accurate and comparative studies before they can be used to reference normal and abnormal thermal variances.

The AAT Website offers specific protocols for image acquisition, depending upon study type that may be used by the imaging technologist for reference.

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