



Review Article

## Consensus of Chinese Experts on the Clinical Application of Medical Infrared Thermography

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## Abstract

Medical infrared thermography (MIT), as a non-invasive functional imaging technique without ionizing radiation, can sensitively and timely detect subtle body-surface temperature changes triggered by physiological and pathological factors in human body. It can objectively reflect the functional status of soft tissues, internal organs, blood vessels and peripheral nerves, and help clinicians locate pain-related lesions and preliminarily judge their pathological properties, making up for the limitations of morphological imaging that mainly display structural abnormalities. This Chinese expert consensus summarizes domestic and international clinical research evidence and practical experience, and provides detailed, operable guidance for the clinical application of MIT, covering standardized examination procedures, image reading principles, differential analysis of thermal signals, and targeted application in various painful disorders. Starting from physiological normal thermal distribution characteristics of human body surface, this consensus conducts comprehensive analysis on the clinical significance of abnormally elevated and abnormally reduced thermal readings, sorts out common interference factors affecting image interpretation, and puts forward practical clinical recommendations for pain-related disease assessment, differential diagnosis and curative-effect follow-up. It aims to standardize clinical operation and interpretation behaviors of MIT, promote its rational clinical popularization, and provide objective imaging basis for auxiliary diagnosis and individualized treatment of pain related diseases.

## Keywords

Medical Infrared Thermography, Human Body Temperature, Pain, Diagnosis, Expert Consensus

## 1. Introduction

All objects with a temperature above  $-273^{\circ}\text{C}$  emit infrared radiation. Infrared detectors have been widely deployed in military, industrial, transportation and other fields. As a constant-temperature organism, the human body acts as a natural infrared radiation source. Medical infrared thermography (MIT) can clearly, accurately and promptly capture minor variations and distribution patterns of body surface temperature arising from diverse pathological and physiological factors.

As a functional imaging modality, MIT complements other modern diagnostic tools, offering novel clinical references and perspectives for early screening, auxiliary diagnosis and therapeutic efficacy evaluation of multiple diseases [1-7]. China began manufacturing and applying MIT equipment in 1976, and currently this technology is used in physical examinations, tumor early warning and therapeutic outcome assessment, cardiac and limb blood supply evaluation, pain disorders management, and meridian research in traditional Chinese medicine (TCM) [8-11].

In 2012, the State Administration of Traditional Chinese Medicine designated MIT instruments as standard equipment for secondary and higher-level TCM hospitals. In 2021, the National Standards Committee released a group standard for pain medicine that recommends MIT examination as one of the pain assessment modalities [8, 12].

Clinically, integrated analysis of MIT images alongside other lab and imaging findings enables visualized identification of pain etiologies, targeted diagnosis and treatment, and objective evaluation of therapeutic response. It furnishes objective evidence to formulate scientific diagnosis-treatment

protocols and diversify clinical thinking for pain management.

## 2. Specifications for Medical Infrared Thermography Examinations

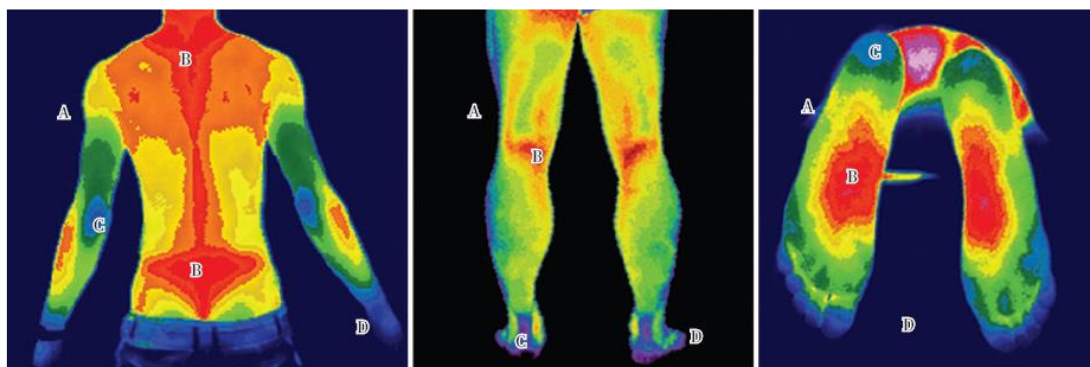
A dedicated independent MIT examination room is recommended. Operators shall guide examinees' body positioning outside the room to fully protect patient privacy. Indoor temperature shall be stabilized at  $(24.0\pm2.0)^{\circ}\text{C}$ ; air conditioning outlets shall be placed away from examinees and imaging equipment to avoid direct thermal/cold airflow or radiant heat interference with subjects and infrared cameras.

Prior to scanning, complete clinical data registration including chief complaints (onset time, location, quality and accompanying symptoms), past medical history, surgical history, menstrual/gestational status, and interventions within the preceding week (electromyography, physical therapy, invasive procedures, etc.). Examinees shall refrain from physical examinations within 30 minutes before scanning, rest quietly for a minimum of 15 minutes, remove mobile phones, bags, jewelry and topical plasters, and avoid scratching the skin to eliminate body surface temperature interference. Subjects shall remove relevant garments and adopt standardized postures during scanning [13-17]. After thermal image acquisition, physicians shall conduct comprehensive interpretation combining clinical history and physical examination to finalize diagnosis and treatment plans [18-21].

### 3. Clinical Interpretation of Medical Infrared Thermography

Advancements integrating human anatomy and pathophysiology have greatly improved the precision of MIT image interpretation in Chinese clinical practice. Multiple temperature

grading systems are available; clinically, colors including red, orange, yellow, green and blue (and their saturation gradients) are commonly used to denote temperature levels [4, 7, 14, 22-24]. (Figure 1).



**Figure 1.** Normal Medical Infrared Thermograms.

Notes: Red = high temperature, blue = low temperature, green = transitional temperature; A: Bilateral symmetry centered on the torso; B: Elevated temperature at concave body surfaces and areas overlying popliteal arteries; C: Reduced temperature at bony/protruding body surfaces; D: Mild temperature reduction at distal extremities.

#### 3.1. Normal Thermal Temperature Distribution on MIT

##### 3.1.1. Regional Temperature Heterogeneity

Skin temperature is bilaterally symmetric relative to the torso midline, yet distinct regional differences exist: Head and neck temperature is highest; ventral torso temperature exceeds dorsal torso temperature; left chest is warmer than right chest; chest temperature is higher than abdominal temperature, upper abdomen warmer than lower abdomen; upper extremities warmer than lower extremities; proximal limb segments warmer than distal segments [17, 25-29].

##### 3.1.2. Physiological Hyperthermic Zones

Regions with abundant blood perfusion, high heat production or poor heat dissipation show elevated temperature: Concave body surfaces including orbital cavities, auricular fossae, supraclavicular fossae, axillae, subxiphoid area, umbilicus, inguinal folds, spinal midline and popliteal fossae. Body surfaces overlying large blood vessels also present varying degrees of temperature elevation [17, 20, 28].

##### 3.1.3. Physiological Hypothermic Zones

Regions with low blood flow, minimal heat production or rapid heat loss exhibit reduced temperature: Bony prominences and protruding surfaces including nasal tip, anterior upper arms, anterior shanks, prepatellar areas and Achilles

tendons. Muscle-rich and adipose tissue accumulation zones (anterior abdomen, buttocks, anterior thighs) are also hypothermic, as are low-metabolism regions such as the anterior trachea or fluid-filled cysts [20, 27].

#### 3.2. Abnormally Elevated Temperature on MIT

Hyperthermia primarily manifests in regions with increased blood perfusion, including acute/chronic inflammation, hyperfunction, myofascial inflammation, benign and malignant neoplasms. Physiological confounders must first be excluded: natural concave surfaces, skin folds, superficial veins, nevi, scars, rashes, and recent physical stimulation (massage, manipulation, acupuncture), plus external interference from mobile phones, backpacks or mechanical friction.

##### 3.2.1. Soft tissue Disorders

Soft tissues encompass all non-osseous structures (skin, mucosa, fascia, muscle, adipose tissue, etc.). Local blood flow changes precede structural morphological abnormalities of soft tissues, presenting as thermal anomalies. MIT therefore detects lesions earlier and more sensitively than structural imaging modalities [17, 21, 29-31].

##### 3.2.2. Vascular Disorders

Vascular occlusion leads to local blood stasis, with MIT delineating the location, severity and scope of obstruction. Temperatures rise proximal to arterial occlusions, at hemangiomas and varicose veins; distal to arterial occlusions, hypoperfusion

causes reduced thermal readings. Distal soft tissue swelling or varicosity distal to venous occlusions induces mild hyperthermia. Distal extremities in diabetic foot and Raynaud's syndrome display characteristic thermal abnormalities at different disease stages [24, 33-36].

### 3.2.3. Neoplastic Disorders

Malignant tumors exhibit rapid proliferation with elevated local blood flow and metabolic activity; the degree and range of hyperthermia on MIT sensitively reflect tumor growth dynamics for early warning. MIT may identify malignant lesions 1-2 months earlier than structural imaging (ultrasound, CT, MRI), which require tumors to reach a critical volume for visualization. Combined with other clinical examinations, MIT improves diagnostic sensitivity and reduces false negatives/positives. Serial MIT scans for suspected or confirmed malignancies enable high-sensitivity monitoring of tumor progression and metastatic spread [8, 20, 37, 38].

### 3.2.4. Visceral Organ Disorders

Lesioned organs display capsular, vascular or glandular hyperplasia/dilation manifesting as focal hyperthermia on MIT. For breast evaluation, mild-to-moderate focal hyperthermia typically indicates mammary hyperplasia, while breast carcinoma presents as moderate-to-severe patchy hyperthermia with linear hyperthermic tracks representing feeding vessels, yielding higher sensitivity than ultrasound and mammography. Focal breast hyperthermia on MIT requires confirmatory ultrasound and serial thermographic follow-up. MIT also captures breast duct thermal changes associated with hormonal fluctuations across menstrual and gestational stages [20, 38-40].

### 3.2.5. Psychogenic, Psychological and Allergic Disorders

Stress, anxiety, depression and other emotional disturbances trigger autonomic dysfunction with systemic cutaneous vascular and metabolic irregularities. MIT demonstrates scattered irregular punctate hyperthermia across the posterior/anterior thorax, after excluding confounders such as sweating, alcohol intake and allergic diathesis. Sleep deprivation manifests as enlarged semicircular/round hyperthermic zones at medial canthi [8, 41].

## 3.3. Abnormally Reduced Temperature on MIT

Hypothermia predominantly arises from diminished regional blood flow secondary to vasoconstriction, luminal stenosis/occlusion, or local cysts/fluid collections. Confounders including bony protrusions, hair, clothing, topical patches and jewelry coverage must be ruled out first.

### 3.3.1. Impaired Blood Perfusion

MIT visualizes tissue hypothermia secondary to circulatory

impairment, providing a novel early screening tool for ischemic disease. It delineates the extent and severity of ischemia caused by arterial stenosis/occlusion and peripheral vasospasm [6, 33, 34, 42, 43].

### 3.3.2. Peripheral Neurological Disorders

Sympathetic nerve fibers originate from the lateral horn of the spinal cord and travel alongside somatic sensory and motor nerves. Neural lesions stimulate sympathetic fibers to release norepinephrine, inducing vasoconstriction and reduced tissue perfusion, producing hypothermia in the corresponding innervated dermatome. Etiologies include spinal cord lesions, neuritis, intervertebral disc herniation and peripheral nerve entrapment [8, 15, 19, 34, 43-46].

## 3.4. Serial MIT Monitoring of Disease Progression

Local blood flow dynamically alters with disease evolution, reflected by shifts between hyperthermia and hypothermia on MIT. Repeat scanning 1-4 weeks after baseline enables objective comparison of thermal patterns to quantify disease progression, therapeutic response, residual lesions or new pathological changes [41, 47-51].

## 3.5. Applications in Traditional Chinese Medicine Research

MIT digitizes and visualizes the TCM concepts of "cold-heat" and "meridians", allowing dynamic observation of cutaneous temperature shifts induced by TCM herbal therapy, manual manipulation and acupoint acupuncture. It provides a unique three-dimensional observational framework for TCM, earning the moniker "TCM thermal CT".

## 4. MIT Analysis for Painful Disorders

Pain constitutes an unpleasant emotional response linked to tissue injury; conventional pain assessment relies solely on subjective patient reports lacking objective biomarkers. Pain signals are transmitted via somatic sensory afferents, which travel in parallel with sympathetic nerve fibers. MIT objectively identifies sites of local inflammation and neural irritation, enabling tripartite pain classification:

- a) Nociceptive pain: Hyperthermia in the symptomatic region.
- b) Neuropathic pain: Hypothermia in the symptomatic region.
- c) Psychogenic pain: Patchy hyperthermia across anterior/posterior thorax.
- d) Mixed pain presents with near-normal thermal readings.

This classification serves as core evidence for formulating pain management protocols [8, 26, 27, 52].

## 4.1. Clinical Recommendations for MIT Scanning in Pain Disorders

Recommendation 1: Adopt a two-step analytical framework for auxiliary diagnosis of painful disorders via MIT. First, correlate the patient's symptomatic region to identify pain-responsible tissues; second, integrate systemic thermal anomalies and comorbidities to design treatment regimens [34, 43, 45, 53, 54].

Recommendation 2: Evaluate MIT findings corresponding to symptomatic pain zones, including fascial, spinal and joint mechanical indicators, to develop comprehensive pain management plans [17, 27, 54].

Recommendation 3: Assist differential diagnosis of complex refractory disorders. Systemic MIT mapping clarifies overall patient status, guides targeted secondary examinations and reduces missed and misdiagnoses [5, 21, 32, 49].

Recommendation 4: Perform serial follow-up MIT scans 2-4 weeks post-intervention to objectively quantify therapeutic efficacy and disease prognosis [16, 34, 55-58].

## 4.2. Rational Interpretation of MIT Findings in Symptomatic Pain Zones

### 4.2.1. Hyperthermia in Painful Regions

Focal hyperperfusion indicates inflammatory activation of peripheral nociceptors, associated with neoplasms, infection, myofascial swelling/atrophy, scar entrapment and other lesions [16, 20, 21, 57, 59-62]. After excluding external cutaneous confounders, clinicians shall correlate hyperthermic anatomical regions with clinical symptoms and physical examination findings to identify nociceptive pain etiologies, prioritizing assessment for vascular and neoplastic pathologies via confirmatory structural imaging [27, 57].

### 4.2.2. Hypothermia in Painful Regions

Neural irritation, entrapment, injury or sensitization of somatic sensory neurons/fibers stimulates adjacent sympathetic fibers to induce vasoconstriction and hypoperfusion in innervated tissue, manifesting as focal hypothermia. Representative conditions include trigeminal neuralgia, spinal radiculopathy, peripheral neuritis/entrapment, peripheral neuropathy (intervertebral disc herniation, spinal stenosis, demyelinating disease, complex regional pain syndrome, Raynaud's syndrome, etc.). After eliminating external thermal confounders, clinicians map hypothermic zones to corresponding nerve distributions to localize the primary lesion site (peripheral vs central nervous system) via neurological physical examination and structural imaging, tracing neural pathways from peripheral to central segments to identify injury loci [13, 24, 55, 56]. Arterial occlusive disease and other confounding factors must also be excluded clinically.

If a hyperthermic focus exists along the afferent neural tract within a hypothermic dermatome, evaluate soft tissue lesions

at that site for nerve entrapment. Common peripheral nerve entrapment syndromes include sciatica, posterior spinal ramus entrapment pain, intercostal neuralgia, brachial plexalgia and median nerve entrapment [12, 48, 56].

### 4.2.3. Near-normal Thermal Readings in Painful Regions

Concurrent hyperperfusion and hypoperfusion factors within the symptomatic zone neutralize thermal gradients, yielding baseline cutaneous temperature. This pattern indicates complex pain etiology, including mixed pain or psychogenic pain. After excluding cutaneous confounders, differential diagnoses include neuropathic pain superimposed on myofasciitis, or arthropathy combined with radiculitis. Clinical examples include post-herpetic neuralgia with residual rash, intervertebral disc herniation concurrent with gluteal fasciitis, facet arthropathy with posterior spinal ramus entrapment, and scapulohumeral periarthritis complicated by cervical nerve entrapment. Sympathetic proximal entrapment induces vasoconstriction while local inflammatory stimulation triggers microvascular dilation, eliminating characteristic hyperthermia/hypothermia patterns in the symptomatic zone. When thermal shifts are minimal on MIT, thorough history-taking (pain exacerbating/alleviating factors), physical examination and structural imaging are required to identify multiple nerve entrapment loci or psychogenic pain [13, 21, 47].

## 5. Conclusion

MIT sensitively characterizes functional status of soft tissues, visceral organs, blood vessels and nerves, facilitating rapid localization and etiological clarification of lesions, guiding confirmatory testing and enabling objective quantification of therapeutic efficacy. Given the complexity and susceptibility of cutaneous thermoregulation to external interference, further research and clinical summary are required to refine standardized MIT application protocols in pain medicine. Clinicians shall prioritize interpretation of thermal patterns in the patient's symptomatic region, followed by systemic assessment of diffuse thermal anomalies, with special attention to suggestive findings including precordial hypothermia, scattered punctate thoracic hyperthermia, hepatic/gastric hyperthermia and mammary hyperthermia, to formulate safe, individualized diagnostic and therapeutic regimens.

## Abbreviations

|     |                               |
|-----|-------------------------------|
| MIT | Medical Infrared Thermography |
| TCM | Traditional Chinese Medicine  |

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Analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing

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## Conflict of Interest

All authors declare no conflicts of interest.

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