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# Use of thermographic imaging in clinical diagnosis of small animal: preliminary notes

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**Abstract**

***Introduction***. The authors, after a description of the physics of infrared thermographic technique (IRT), analyze the reading of images and the main applications in the veterinary field, compared to the existing literature on the subject and to their experimental researches. IRT lends itself to countless applications in biology, thanks to its characteristics of versatility, lack of invasiveness and high sensitivity. Probably the major limitation to its application in the animal lies in the ease of use and in its extreme sensitivity.

***Materials and methods***. From September 2009 to October 2010, the experimental investigation with the thermo camera took into consideration 110 animals (92 dogs and 18 cats), without any selection criteria. All patients were brought to the Faculty of Veterinary Medicine in Milan University by the owner, to be examined by a specialist, or to undergo one of the following diagnostic procedures: X-rays, computed tomography, or ultrasound examinations; finally some patients were brought in for surgical procedures. With the consent of the owner, 1 to 10 thermographic images were recorded from each clinical case.

***Results.*** In this first experimental investigation, thermography has shown a high sensitivity (100%), but a low specificity (44%). This figure excludes the use of thermal imaging technology to replace other imaging techniques such as radiography, computed tomography and magnetic resonance imaging. Furthermore, it does not show any ability to recognize the etiology of the disease, but only the thermal alteration, and this is restricting its use. However, this experimental study has demonstrated that thermography can be used in veterinary medicine, and specifically in dogs and cats. It is hoped that in the field of targeted diseases this technique will become an important tool for diagnostic purposes by using working protocols validated and repeatable.

**Key words**
- thermography
- animal production
- welfare

## INTRODUCTION

The first trials of our research group concerning the thermographic technique in veterinary medicine were focused on livestock animals as a non invasive method to analyze the welfare conditions of animals [1-3].

The use of thermography is currently very limited in dogs and cats. In the last years, a trial was conducted in a police dog center, located in Castiglione del Lago (Italy), to see whether the thermography could be used for the evaluation of the behavioral and physiological welfare of working dogs [4].

The only diagnostic study concerned the cranial cruciate ligament and the ability of thermography to differentiate between a normal knee and a pathologic one. The camera showed an increased temperature at the level of the knee, joined with rupture of the cruciate ligament, in 75%-85% of cases [5].

Thermoregulation involves several phenomena that the organism puts in place, in order to maintain a constant body temperature, despite variations in the environmental temperature. In animals the production of heat comes from oxidative processes of energy metabolism, from muscle activity and nutrition. Heat losses occur but the vast majority (70%) by radiation and conduction and, secondarily, through sweat, breathing and intestinal and urinary excretory activity. In warm-blooded animals (homoeothermic), the mechanisms of thermoregulation involve responses to somatic, en-

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docrine, behavioral and especially autonomic system, through which the extent of losses and the production of heat are adequate. The mechanisms activated by cold temperatures are: muscle activity, secretion of adrenaline (epinephrine) and thyroid stimulating hormone, increased appetite (all factors that increase heat production), as well as cutaneous vasoconstriction and horripilation and curled up reflexes, which tend to reduce heat loss. On the contrary, warm temperatures will induce: the cutaneous vasodilation, increased pulmonary ventilation and perspiration, all these promote heat loss. These stimuli together decrease appetite, motor activity and secretion of pituitary gland by slowing down the metabolism, and thus heat production. All the thermoregulatory reflex mechanisms are integrated by the hypothalamus.

Body temperature may show physiological and pathological variation (hyperthermia). The physiological changes depend on the estrous cycle, season, age, digestion and pregnancy [6]. Hyperthermia can be divided into non-febrile and febrile. Fever is associated with alterations of hypothalamic regulatory center, due to exogenous or endogenous pyrogens. Hyperthermia is an elevation of body temperature above the level of hypothalamic threshold, due to insufficient heat dispersion [7].

Limited variations in temperature are generally due to local processes. An increase in local temperature might be caused by an inflammatory process, traumatic or infectious in origin, or to neoplastic neo-angiogenesis. On the contrary, an anatomical area colder than the surrounding body parts, can be due to ischemic or necrotic phenomena, in which a portion of the tissue does not receive an adequate blood supply.

The purpose of this study is to test the usefulness of thermography as an aid for the diagnosis of different diseases of the dog and the cat.

## MATERIALS AND METHODS

The thermo-camera used for the present study is the "AVIO TVS 500" (www.inprotec.it) (*Figure 1*). It is a portable device, able to display on a LCD monitor real time images. Being also equipped with a multi-function joystick, its use is quick and easy. Once recorded, the images can be stored on compact flash card in various formats. The weight of the camera is about 1.5 kg, making it easily handled, without the need of any mechanical support. The camera can be used both indoors and outdoors, further, it can be used in sunny days, as it is equipped with an uncooled micro bolometer sensitive to radiation of wavelengths between 8 and 14 μm, which makes the instrument solar radiation proof.

### *Period and housing*

From September 2009 to October 2010, the experimental investigation with the thermo camera took into consideration 110 animals (92 dogs and 18 cats), without any selection criteria. All patients were brought to the Faculty of Veterinary Medicine in Milan University, Italy, by the owner, to be examined by a specialist, or to undergo one of the following diagnostic procedures: X-rays, computed tomography, or ultrasound examinations; finally some patients were brought in for surgical procedures. With the consent of the owner, 1 to 10 thermographic images were recorded from each clinical case.

The thermo camera operator did not interfere with the clinical examination of the patient, and avoided any physical contact with the animal. In some cases, the operator was aware of the disease that was affecting the patient, but in other cases he/she did not know anything about it. In most cases the animal was alert and therefore it was completely free to move in the examination room or on the table; in other cases, the patient was contained physically, or pharmacologically.

15 out of 110 cases proved to be perfectly healthy (5 were pregnant females), after clinical examination, or additional diagnostic tests, while 96 out of 110 patients had some kind of disease. The pathological patients were then divided in three groups: healthy, oncologic and not-oncologic (*Figure 2*).

## RESULTS

Results are different depending on the kind of disease, anatomical location and length of hair of the animal. The approach followed by the authors is to search for specific distributions of temperature (mostly asymmetric) and presence of hot spots (hyperthermia) or cold spots (hypothermia) in the pathological site.

In the *Tables* the obtained results are shown. For convenience we used the symbols (-, +, + +) in order to explain the outcome of the display with infrared imaging to which each individual case is associated.

The 65 non-cancer cases were divided into 9 subgroups based on the etiology of the disease in *Table 1*.

The subgroup "other" includes 2 non-infectious dermatitis (cases 77 and 97) and a fluid-filled lesion that is suspected to be a keratinic cyst. Further, in this group there is another canine case (75), where a cytology sample taken from the subcutis of the thigh, gave inconclusive result. Unfortunately, the owner never came back for a follow-up.

Case 67 is a dog with bilateral hip implants, that were put in place few months before our thermography scanning. The patient was completely unable to walk: radiographic examination could not point out that the hip prosthesis, especially the left one, caused acetabular injuries.

### *Internal medicine*

Thermographic images did not show any change in temperature in 14 healthy subjects, as well as in patients with diseases related to abdominal or thoracic organs, regardless of their etiology: this is due to the low penetration capability of the technique. These finding would exclude the use of thermography as a diagnostic help, in internal medicine.

### *Dermatology*

Infrared imaging is able to spot only the skin changes of the short-haired dogs (such as Bulldogs, or Dobermans). In these dogs an increase of temperature is observed in inflamed tissues, as well as in the naked area around the eyes.

Because most dermatologic lesions are detectable

**Table 1**
Pathology location divided per species (see legenda) and breed

| no. | S | BREED | PATHOLOGY LOCATION | PATHOLOGY |
|---|---|---|---|---|
| **1** | D | Hybrid | - | elbow displasia |
| **2** | D | Pinscher | left knee | patella dislocation |
| **3** | C | Common European | left shoulder | fracture |
| **4** | C | Common European | tail connective tissue | fibrosarcoma |
| **5** | C | Common Europan | infrascapular connective tissue | fibrosarcoma |
| **6** | D | Labrador | - | - |
| **7** | D | Breton | rachis | discospondylitis |
| **8** | D | German Sheperd | rachis | lumbosacral stenosis |
| **9** | D | Labrador | rachis | intra vertebral disc degeneration |
| **10** | D | Welsh Corgi | rachis | intra vertebral disc degeneration |
| **11** | D | Volpino | rachis | subluxated vertebra |
| **12** | D | Welsh Corgi | right and left elbow | arthrosis |
| **13** | CD | Pug | larynx | laryngeal collapse |
| **14** | D | Hybrid | left knee | anterior cruciateligament breaking |
| **15** | D | Basenji | right nasal cavity and eye | carcinoma |
| **16** | D | Labrador | right elbow | ulna fracture |
| **17** | C | Common European | basin left | acetabulum fracture |
| **18** | D | German Sheperd | right elbow | dysplasia |
| **19** | D | Pitbull | rachis | subluxation |
| **20** | D | Siberian Husky | rachis | spondylarthrosis |
| **21** | D | German Sheperd | rachis | paraparesis |
| **22** | D | Dachshund | nasal cavitites | rhinitis bilateral |
| **23** | D | Boxer | rachis | spondylarthrosis |
| **24** | D | Lhasa Apso | rachis | intra vertebral disc degeneration |
| **25** | C | Siamese | rachis | vertebral subluxation |
| **26** | D | Dachshund | rachis | intra vertebral disc degeneration |
| **27** | D | German Sheperd | breast | carcinoma |
| **28** | D | Pitbull | skin | mastocitoma |
| **29** | D | Labrador | rachis | vertebral subluxation |
| **30** | D | Yorkshire | right and left knee | patella dislocation |
| **31** | D | Bulldog | scrotum and foreskin, elbow | dermatitis, dysplasia |
| **32** | D | Golden Retriever | left shoulder | hemangiosarcoma |
| **33** | D | Labrador | rachis | intra vertebral disc degeneration |
| **34** | D | German Sheperd | rachis | subluxation |
| **35** | D | Hybrid | jaw – bone graft | left humerus |
| **36** | D | German Sheperdo | left knee | anterior cruciate ligament rupture |
| **37** | D | Yorkshire | bone | mieloma multiple |
| **38** | D | Shitzu | stomach | CHPG (chronic hypertrophic pyloric gastropathy) |
| **39** | D | Maltese | left knee | osteosynthesis |
| **40** | D | Weimaraner | left thigh skin | mastocitoma |
| **41** | C | Common European | right eye connettive scapula | melanoma; fibrosarcoma |
| **42** | C | Common European | left elbow | proximal ulna fracture |
| **43** | C | Common European | bladder and urethra | FLUTD (Feline Lower Urinary Tract Disease) |
| **44** | D | Dachshund | | tracheitis |
| **45** | D | Hybrid | distal femur | osteosarcoma |
| **46** | D | Boxer | chest | effusion |
| **47** | D | American Staffordshire | - | - |
| **48** | D | Hybrid | kydney | renal failure |
| **49** | C | Common European | stomach intenstine | gastroenteritis |
| **50** | D | Setter | outer ear | otitis |
| **51** | D | Labrador | left knee | anterior cruciate ligament rupture |
| **52** | D | Hibrid | right nasal cavity | transitional cell carcinoma |
| **53** | D | Basenji | tonsils, lymph nodes | adenocarcinoma |
| **54** | C | Common European | connective infrascapular | fibrosarcoma |

(continues)

**Table 1** (Continued)

| no. | S | BREED | PATHOLOGY LOCATION | PATHOLOGY |
|---|---|---|---|---|
| **55** | D | Boxer | vertebrae | spondylosis |
| **56** | D | German Sheperd | rachis | vertebral subluxation |
| **57** | D | Poodle | rachis | intra vertebral disc degeneration |
| **58** | D | Hybrid | tail | sarcoma |
| **59** | D | German Sheperd | rachis | paraparesis muscle wasting |
| **60** | D | German Sheperd | rachis | vertebral subluxation |
| **61** | D | Boxer | hips | dysplasia |
| **62** | C | Common European | right flank subcutis | fibrosarcoma |
| **63** | C | Common European | nasal cavity | carcinoma |
| **64** | D | German Sheperd | blood | hypercalcemia |
| **65** | D | Bergamo Sheperd | liver | liver disease |
| **66** | D | German Sheperd | breast | |
| **67** | D | Labrador | left hip | arthritis arthritis |
| **68** | D | Labrador | skin | lymphoma |
| **69** | D | Hybrid | - | - |
| **70** | D | Labrador | breast | |
| **71** | C | Common European | subcutaneous infrascapular | cystic lesion |
| **72** | D | Dobermann | forelimbs | interdigital dermatitis |
| **73** | D | Hound | systemic | leishmaniasis |
| **74** | C | Main Coon | neck and supraorbital skin | mastocytoma |
| **75** | D | Hybrid | right thigh skin side | neoformation |
| **76** | D | Common European | left nasal cavity | chronic rhinitis |
| **77** | D | Common European | lip skin groin | allergic dermatitis |
| **78** | D | Hybrid | skin | demodicodis |
| **79** | D | Sharpei | eyelids outer ear | entropion otitis |
| **80** | D | Dachshund | - | pregnancy |
| **81** | C | Dachshund | - | pregnancy |
| **82** | C | Dachshund | - | pregnancy |
| **83** | C | Dachshund | - | pregnancy |
| **84** | C | Hybrid | - | - |
| **85** | C | Bulldog | - | pregnancy |
| **86** | C | Bulldog | skin | piodemodicosi |
| **87** | C | Bulldog | kin | piodemodicosi |
| **88** | C | Chihuahua | perianal skin | injury from scratching |
| **89** | C | Poodle | breast | |
| **90** | C | Golden Retriever | - | - |
| **91** | C | German Sheperd | breast | |
| **92** | C | Boxer | III eyelid lacrimal gland | prolapse |
| **93** | C | Akita Inu | perianal skin | tracheobronchitis |
| **94** | C | Hybrid | skin | mastocitoma |
| **95** | C | Hybrid | peri-penile skin | mastocitoma |
| **96** | C | Setter | lymphocytes | follicular lymphoma |
| **97** | C | Hybrid | left flank subcutis | idiopathic dermatitis |
| **98** | G | Common European | middle ear | otitis media |
| **99** | C | Hybrid | - | - |
| **100** | C | Shitzu | abdomen subcutis | lipoma |
| **101** | C | Golden Retriever | - | - |
| **102** | C | German Sheperd | finger subcutis | atopic dermatitis |
| **103** | C | Labrador | medial skin of right elbow | postoperative wound |
| **104** | C | Cane Corso | ventral neck subcutis | abscess |
| **105** | C | Poodle | toes and forehead skin | dermatitis |
| **106** | C | Pekinese | - | - |
| **107** | C | Border Collie | lymphocytes | lymphoma |
| **108** | C | Setter | lymphocytes | follicular follicular lymphoma |
| **109** | C | Cocker Spaniel | intestinal lymphocytes | follicular lymphoma |
| **110** | C | Border Collie | lymphocytes | lymphoma |

S = species; D = dog; 5 C = cat

**Figure 1**
The camera AVIO TVS 500.

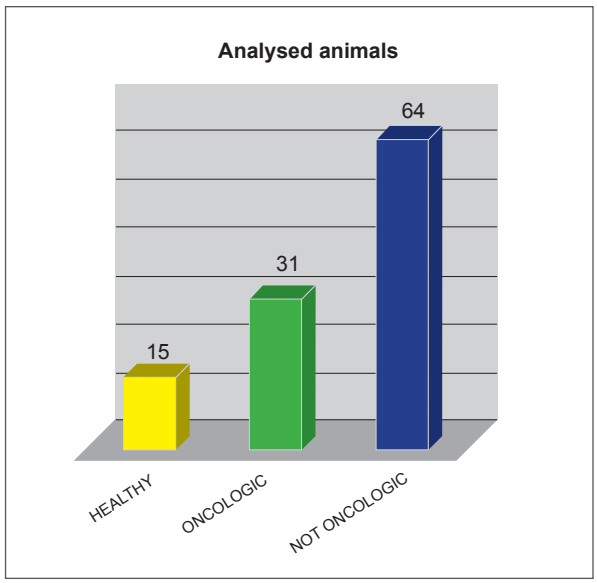


**Figure 2**
Analyzed animals grouped as: healthy, oncologic, not oncologic.

with a simple clinical examination, and however, the alopecia resulting from the disease processes denotes an increase in temperature, thermography is considered almost useless in the field of dermatology. However, it would be interesting to verify the usefulness of thermographic techniques in other skin diseases to test the ability of the technique to differentiate between infectious and non infectious dermatitis.

### *Orthopedics and neurology*

Infrared imaging is extremely interesting in orthopedics, as it can show all the problems related to fractured bones and ruptured ligaments, even if results can be more or less evident (*Figure 3* and *Figure 4*).

However, thermography was not able to highlight changes due to dysplastic hips and elbows, with the exception of a case that developed arthritis (case 31).

Similar results were obtained on all the neurological disorders related to the orthopedic spinal problems, such as vertebral subluxation, lumbosacral stenosis, degeneration of the intervertebral disc. Interestingly, many of these lesions are clearly visible in the human patient, with thermography. The authors believe that the negative results in dogs and cats are due to the shielding effect exerted by hair.

### *Oncology*

In oncology, the results are different depending on the location and size of the tumor. In two cases (an osteosarcoma of the femur, case 45, and an hemangiosarcoma of the shoulder, case 32), where the tumors had a considerable size, it was rather easy to see the lesions with thermography (*Figure 5*); this is in contrast to malignant tumors of the fibrous connective tissue, represented by 6 cases of fibrosarcoma of the cat, that although large, were not visible with the use of thermography.

Breast cancers show a variable appearance of infrared images, which cannot be interpreted uniquely, to date. The mammary region shows some areas with temperature much higher, compared to areas nearby, but not always the tumors and these regions are overlapping.

The cases of lymphoma showed no particular changes in imaging, except for a follicular lymphoma that shows a high temperature in the region corresponding to the prescapular lymph nodes.

## DISCUSSION

### *Advantages and problems related to thermographic technique*

Thermography has many benefits, first of all, it is a completely non-invasive method. In veterinary medicine, the clinician may easily face "uncooperative patients", or even aggressive ones, and this problem may be increased due to pain or fear: thermography can give us some preliminary information on the location of the problem/disease. Secondly, the ease of handling a thermo camera and the simplicity of use of the technique, make it easily accessible to almost anyone. The technique does not imply long scanning time, as infrared images are obtained immediately, stored in digital format and, having a computer available, they can be visualized in few seconds. By an economic point of view, once the cost of the camera and software have been amortized, the cost of a single image is very low.

One problem may arise trying to take good quality images from animals free to move. It is also often difficult to take good images from different angles: even in sedated, or anesthetized animals, some side of the patient may be impossible to investigate.

Another limitation of thermography is related to the scanning capacity in depth: only few cm from the body surface can be penetrated and analysed; further, it is possible that external conditions and other disorders do affect the temperature reading.

Dogs and cats with medium and long hair are almost not investigable by infrared thermography, because of the thickness of the hair; in those patients, only the lesions that are located in hairless areas, such as the eye, nose, oral cavity, ear and peri-anal area, can be evaluated by thermography.

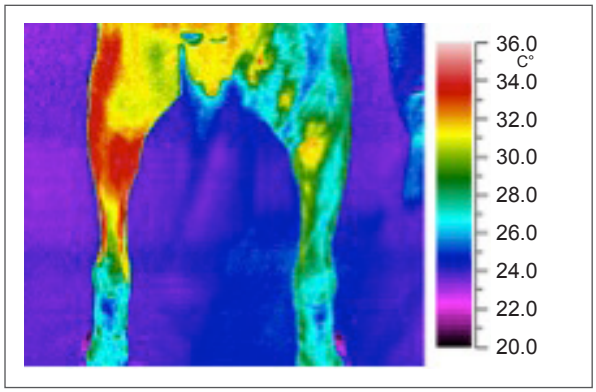


**Figure 3**
Thermography of the hind legs of a dog (case 14) operated by Tibial Tuberosity Advancement (TTA) in his left knee, caudal view.

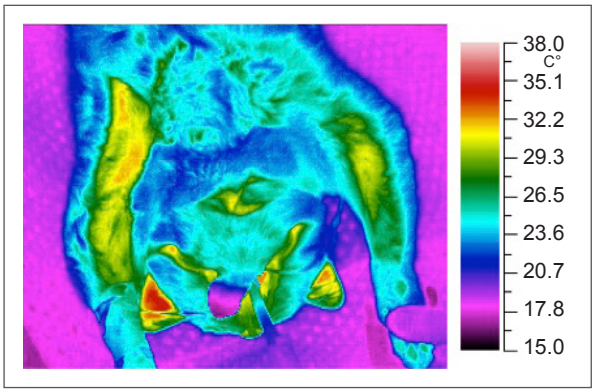


**Figure 4**
Thermographic image of a cat (case 3) with a fractured left shoulder.

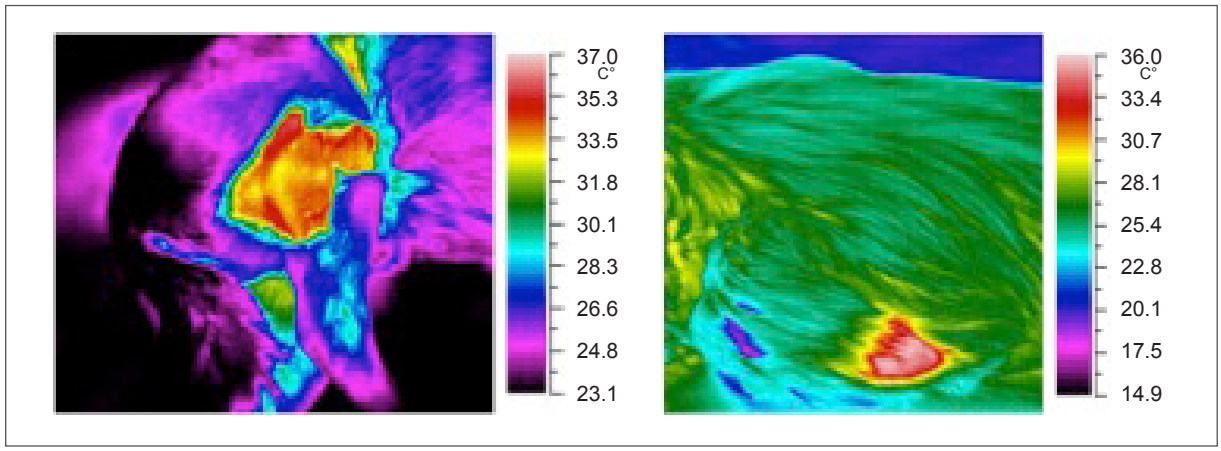


**Figure 5**
Thermographic images of the left shoulder of the emangiosarcoma left) and of the osteosarcoma of the right femur (right).

## CONCLUSION

The limitations of this screening are associated with the relative small number of samples, which could affect any type of disease; furthermore, in many cases there is not a definitive diagnosis, because some owners did not came back for deeper diagnostic testing.

In this first experimental investigation, thermography has shown a high sensitivity (100%), but a low specificity (44%). This figure excludes the use of thermal imaging technology to replace other imaging techniques such as radiography, computed tomography and magnetic resonance imaging. Furthermore, it does not show any ability to recognize the etiology of the disease, but only the thermal alteration, and this is restricting its use.

However, this experimental study has demonstrated that thermography can be used in veterinary medicine, and specifically in dogs and cats. In fact, excluding some diseases affecting the deepest organs, and the animals with long and thick coat, the complete non-invasiveness, the total absence of risks of use and low cost of single shot, make the thermographic technique an important tool in the case of fractures, either for the anatomical location of the lesion , and for monitoring the development of certain inflammatory processes; also, thermography is useful for the screening of certain diseases, such as alterations of the nasal mucosa, especially when clinical examination is not able to give conclusive results.

This experimental investigation opens the door to future studies on the use of thermography in dogs and cats. It is hoped that in the field of targeted diseases this technique will become an important tool for diagnostic purposes by using working protocols validated and repeatable.

### *Conflict of interest statement*

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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