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Use of infrared thermal camera in acute scrotal pain: a prospective study

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Abstract

Background and objectives: Infrared thermal (IR) camera is used to assess various clinical conditions such as diabetic foot, carotid artery stenosis, and superficial infection. The present study was designed to determine the usefulness of IR thermal camera in scrotal temperature measurement before color Doppler ultrasonography (CDUS) in patients admitted to the emergency department with acute scrotal pain.

Method: This study was prospectively conducted on 49 patients with acute scrotal pain and 30 control participants. The findings of CDUS and scrotal temperature measurements by an IR camera were separately evaluated by different physicians. In all patients, temperature measurements with IR camera were made under the same environmental conditions.

Results: Of the 49 patients included in the study, four were diagnosed with torsion, 12 with epididymitis, 4 with orchitis, 3 with epididymo-orchitis, and 2 with varicocele. A significant difference was observed between the scrotal temperature of the patients with scrotal pain and the mean testicular temperature of the control group based on the IR camera measurement ($p<0.05$). IR camera did not detect any difference between the two testicles of the same person in the patient group ($p=0.615$). Although the lowest temperature was in testicular torsion, the patients' scrotal temperature did not significantly differ according to their diagnoses ($p=0.087$).

Conclusion: Testicular temperature measured by IR device was lower in patients presenting with scrotal pain compared to normal individuals. Although not statistically significant, the lowest temperature was found in cases of testicular torsion. IR camera may be useful in triage when used in conjunction with physical examination in patients presenting with acute scrotal pain.

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Introduction

Scrotal pain can be primary or reflective. The differential diagnosis of acute scrotal pain includes testicular torsion, torsion of the testicular extensions, epididymitis, orchitis, incarcerated hernia, trauma and vasculitis. Testicular torsion should be considered first in acute scrotal pain due to potential infarction and infertility. Delays in the diagnosis of testicular torsion can cause testicular necrosis and testicular loss. It is important to diagnose patients presenting to the emergency department with acute scrotal pain promptly since emergency surgery is indicated in the presence of testicular torsion [1].

In case of acute scrotal pain, laboratory investigations and imaging methods are used along with a physical examination for diagnostic purpose. For the detection of testicular pathologies, the most used and beneficial imaging method is Doppler ultrasonography, but this procedure

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requires experienced personnel. Radiology physicians are not always available in the hospital, and there may be concerns of emergency physicians about requesting ultrasonography. Also, ultrasonography may not be available in every healthcare institutions in low economic countries [2,3].

The infrared (IR) thermal camera, which has been introduced to the field of medicine, assists in the early diagnosis of various clinical conditions. It is used in various clinical conditions such as diabetic foot, carotid artery stenosis, and superficial infection. In case of vascular stenosis or skin infection, temperature changes can occur in the skin. While the temperature increase is less in stenosis cases, it is higher in cases of infection. It is possible to detect these changes using an IR thermal imager at low cost [4-6].

This study aimed to examine the diagnostic value of IR thermal camera images of patients presenting with acute scrotal pain by comparing them with color Doppler ultrasonography (CDUS). We hypothesized that the temperature measurements by an IR thermal imager would low in case of testicular torsion and high in the presence of infection. We assume that IR thermal camera can help physicians in healthcare settings lacking facility for CDUS.

Methods

Study design and setting: This prospective controlled study was conducted at the Emergency Department of University Adiyaman Research and Education Hospital. The study was approved by the ethics committee of the hospital (ethics committee decision number: 2016/185, date: 26.09.2016). Informed consent was obtained from the each participant. The study protocol was carried out in accordance with the principles of the Declaration of Helsinki.

Selection of participants: The study population consisted of all patients over 16 years of age that presented to the emergency department with acute onset of scrotal pain. The suitability of the patients was determined by the emergency physician. Physicians participating in the study were trained on the use of CDUS and IR camera. For the control group, volunteers over the age of 16 years, who did not have any comorbidities, testicular pain, increased temperature, or swelling, were selected. Patients younger than 16 years of age and those that did not agree to participate in the study, as well as those with any additional organic pathology were not included in the study.

Study procedures: The cases included in the study were taken to a room in the emergency department equipped for ultrasonography and thermal imaging. The room where the imaging was performed was not exposed to direct sunlight and did not contain any heat source or lighting equipment that could cause errors in thermal imaging. Three teams were involved in the imaging process: one for recording the thermal image, one for performing CDUS and one for reviewing the data. The data obtained from these teams were provided that each was blinded to the others' evaluation. All patients and controls were kept in the room prepared for the study with their scrotum uncovered for 5 minutes in order to minimize the temperature differences that could be caused by the clothes and ambient temperature. While the patient was in the supine position, a thermal camera was focused from a distance of approximately 50 cm and three consecutive images of the scrotum were taken for both sides. After taking the thermal images CDUS was performed on the patient and control groups.

Methods of measurements: Using software, background temperatures were completely removed from the thermal images to increase sensitivity, and thus pure testicular temperatures were obtained. In addition, two testes were separated independently by creating separate heat vectors. The generated heat vectors were used in the statistical asymmetry analysis of the diseased and intact testes. In this analysis, mean, median, standard deviation, variance, kurtosis, skewness and entropy values were calculated to allow for a completely objective evaluation in distinguishing the presence of a disease. Images taken from the patients with a thermal camera were evaluated to make a diagnosis using various image processing techniques and statistical calculations.

The Logiq P6 (General Electric Healthcare, 2008, Germany) ultrasonography device with 12 MHz

Figure-1: *The samples showing measurement with IR device*

linear and 5 MHz convex probes were used for the CDUS examinations. The Testo 875-I (Testo SE & Co, UK) thermal imager was used for thermal imaging. This camera has a 160×120 pixel detector and can record images at a resolution of up to 320×240 pixels with its super resolution feature and detect a temperature difference of 0.05 °C (Figure 1).

Statistical analysis: The distribution analysis of the data obtained from this study was performed using the Kolmogorov-Smirnov test. The independent-samples t-test was used for the binary comparisons of independent and normally distributed data while the Mann-Whitney U test was conducted for the binary comparisons of independent and non-normally distributed data. The results of the nominal value groups were analyzed using the chi-square test. The results were expressed as mean ± standard deviation. For statistical analyses, SPSS v. 18.0 was used. P <0.05 was considered to be statistically significant in all comparisons.

Results

During the study period, 70 patients with scrotal pain were evaluated, of these patients, 21 (30%) were excluded based on exclusion criteria. Finally, a total of 49 patients with scrotal pain were included in the study. Thirty individuals were recruited for the control group (Figure-2). The mean age was 28.5 ± 11.7 years for the patient group and 27.8 ± 11.4 years for the control group.

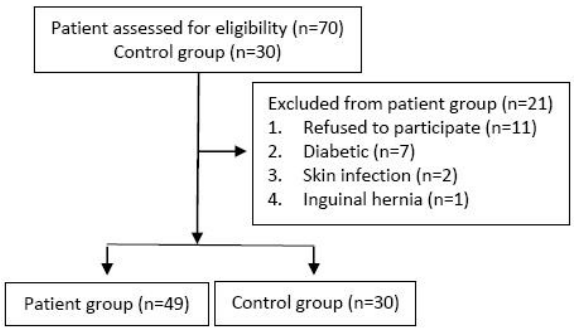

Figure-2: *Flow chart showing the enrollment of the study population*

According to the reports of the CDUS, epididymitis was present in 24.5% of the patients, orchitis in 8.2%, epididymo-orchitis in 6.1%, torsion in 8.2%, varicocele in 4.1%, and normal findings in 49% cases (Table-1). The physical examination findings of the patients varied depending on their diagnoses. There were differences in relation to the cremaster reflex and Prehn's sign according to the diagnoses. These findings were negative in all patients with torsion while they were positive in most of the cases with normal findings (Table-2).

Table-1: *Doppler ultrasonography results of patients (n=49)*

Diagnosis by Doppler ultrasonography	Number (%)
Epididymitis	12 (24.5)
Orchitis	4 (8.2)
Epididymo-orchitis	3 (6.1)
Torsion	4 (8.2)
Varicocele	2 (4.1)
Normal	24 (49)
Total	49

There was a statistically significant (p <0.001) difference between the mean testicular temperature of the group with scrotal pain and the control group based on the IR camera measurements (Table-3). The mean testicular temperature of the group with scrotal pain was 33.06 ± 1.21°C, while the mean testicular temperature of the control group was 34.09 ± 0.73°C. Temperatures of the diseased and intact testicles of the patients were also evaluated with IR camera and no significant difference was found (p=0.615) (Table-3). When the IR measurements were evaluated according to the diagnoses, the lowest temperature was in testicular torsion (31.93 ± 0.56 °C). The highest temperature was recorded in epididymitis (33.40 ± 1.34 °C). However, the mean testicular temperature did not significantly differ according to the types of diagnosis (p = 0.087) in patient group (Table-3).

Table-2: *Analysis of the cremaster reflex and Prehn's sign according to the diagnoses (n=49)*

Definitive diagnosis	Number of case	Cremaster reflex		Prehn's sign	
		Positive n (%)	Negative n (%)	Positive n (%)	Negative n (%)
Epididymitis	12	9 (75)	3 (25)	6 (50)	6 (50)
Orchitis	4	3 (75)	1 (25)	3 (75)	1 (25)
Epididymo-orchitis	3	1 (33.3)	2 (66.6)	1 (33.3)	2 (6.6)
Torsion	4	0 (0)	4 (100)	0 (0)	4 (100)
Varicocele	2	1 (50)	1 (50)	1 (50)	1 (50)
Normal	24	14 (58.3)	10 (41.7)	16 (66.6)	8 (33.3)
Total	49	28 (57.1)	21 (42.9)	27(55.1)	22(44.9)

Table-3: *Scrotal temperature according to the diagnoses as measured by IR camera*

Study group and clinical condition	Number	Scrotal temperature (°C)	p value
Patient group	49	33.06 ± 1.21	<0.001
Control group	30	34.09 ± 0.73	
Patient group			
Painful testis	49	33.06 ± 1.21	0.615
Normal testis	49	33.18 ± 1.16	
Patient group-diagnosis			
Epididymitis	12	33.40 ± 1.34	
Orchitis	4	33.38 ± 2.35	
Epididymo-orchitis	3	32.60 ± 1.22	0.087
Torsion	4	31.93 ± 0.56	
Varicocele	2	32.01 ± 0.44	
Normal	24	33.17 ± 0.92	

Discussion

There are only a few human studies on the use of an IR thermal imager for testicular pathologies. Most of the studies involving scrotal pathology were conducted on animal models. Arumalla conducted a study on testicular torsion in sheep and skin infection in humans in order to investigate the effectiveness of thermal cameras [7]. The aim of the author in that study was to show the temperature decrease due to decreased blood circulation in testicular torsion of sheep, and the increase in temperature due to inflammation in skin infections (abscess, cellulite, etc.) with a thermal camera. The authors concluded that infrared thermal camera were effective in detecting skin infection and testicular torsion and therefore, could be used in humans. Another study conducted by Yanmaz et al [8] on the extremity diseases of horses, reported that thermography could be used in routine clinical practice as an auxiliary diagnostic method to identify and diagnose lesions of soft and hard tissues of the horse extremity. A study conducted on pigs reported that IR thermal imager could effectively detect decreased surface temperature following arterial and venous thrombosis [9],

In human, Saxena et al [4] reported that IR camera measurements performed on the skin were significantly lower in patients with carotid artery stenosis. In another study, Doremalen et al [5] suggested that an IR camera was a good screening device for assessing diabetic foot. A study that monitored surface temperature by IR thermal camera in the postoperative management of free tissue transfers showed lower surface temperature in flaps with thrombosis than normal flaps [10]. Earlier, few studies on human reported elevated scrotal temperature in patients with varicocele when assessed by IR thermal camera [11,12].

In our study, a significant difference was observed when the temperature of the testicles of individuals in the scrotal pain group and the control group were compared. Temperature was lower in the scrotal pain group. In our study, the lowest scrotal temperature is in torsion patients. But there was no significant difference between patient diagnoses and body temperature which could be due to the low number of patients. However, there was no significant difference between the temperatures of the diseased and intact testicles measured by an IR thermal camera in the same individuals. This could be due the proximity of the diseased and intact testes affected the temperatures.

There was some limitation in our study. The study had small number of cases. But this study may be valuable as it examined for the first time the testicular temperature in humans by an IR camera in variety of scrotal pathology. Differences in temperature values of disease groups according to diagnoses and comparison with values in normal individuals could not be examined. Further studies are needed for comparisons with larger number of cases.

In this study, a lower temperature is significant in acute scrotal pain. The management of acute scrotal pain in the emergency department requires the evaluation of patient by physical examination and imaging findings together. Imaging or physical examination alone is not sufficient for a diagnosis. Testicular temperature measured by IR device was lower in patients presenting with scrotal pain compared to normal individuals. An IR camera could not replace CDUS in acute scrotal pathologies; however, it may be beneficial in triage when used together with the physical examination of patients presenting with acute scrotal pain. We think that IR thermal camera can help physicians in low economic settings and in healthcare facilities where opportunities for CDUS are limited.

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