Assessment of testicular core temperatures using microwave thermography

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A new method for the reliable assessment of testicular core temperature using microwave technology is presented. This study was designed to assess whether alterations in testicular thermoregulation could be reliably demonstrated in patients with clinically apparent varicoceles (n = 36), in those with idiopathic male infertility (n = 52) and in fertile donors (n = 20) using this new microwave thermographic technique. The measurements obtained were found to be reliable and reproducible. Testicular core temperature measurements were significantly different between the groups (P < 0.001). Furthermore, there was a temperature gradient between the scrotal neck and the testicular core in all groups; testicular core temperatures were lower than scrotal neck temperatures. The magnitude of this temperature difference was also significantly different (P < 0.001) between the groups. Microwave testicular thermography is a new technique that is safe and accurate. Preliminary results suggest altered testicular thermoregulation in a group of patients with impaired spermatogenesis with and without varicocele. Testicular temperature profiles obtained by microwave thermography may be of value in the assessment of infertile men with or without a varicocele.

Key words: temperature/testis/thermography

Introduction

Elevated intratesticular temperature was first suggested as a cause of defective spermatogenesis in undescended testes (Crew, 1921). Many studies have shown that elevation of intratesticular temperature adversely affects spermatogenesis (Robinson et al., 1968; Fahim et al., 1975; Bedford, 1991) and extrinsic thermal stress to the scrotum has long been known to cause alterations in semen reflecting spermatogenic damage (Lynch et al., 1986; Zorgniotti and Sealfon, 1988; Mieusset and Bujan, 1995). It has been reported that patients with poor semen quality with or without an evidence of varicocele had bilateral intrascrotal temperatures which were significantly higher than those of normal volunteers with excellent semen quality (Zorgniotti and MacLeod, 1973). However, more recently, a conflicting study measuring scrotal skin temperature via an electronic probe reported no difference between healthy volunteers and varicocele patients (Lund and Nielsen, 1996). In addition, it was concluded that raising scrotal temperature by 0.8–1.0°C did not affect spermatogenesis or sperm function (Wang et al., 1997). Conversely, it has also been shown that elevation of testicular temperatures by only 1–1.5°C in two experimental species of mammals clearly results in some reduction in testis size, in a lower sperm production, and in the production of some abnormal forms (Bedford et al., 1982).

The World Health Organization (WHO, 1985) advised the use of testicular temperature in conjunction with Doppler sonography in the investigation of infertile men with varicocele. There is therefore a need for a reliable, reproducible and easily applied method of testicular core temperature measurement to be used in the investigation of some infertile men. We present a new method using microwave technology for the reliable assessment of testicular core temperature. This study was designed to assess whether alterations in testicular thermoregulation could be reliably demonstrated between patients with clinically apparent varicoceles, in those with idiopathic male infertility and in fertile donors.

Materials and methods

During the course of 12 months between May 1997 and April 1998, 90 infertile men with a diagnosis of idiopathic oligozoospermia or varicocele and 20 healthy sperm donors were recruited into the study. Of the recruited 90 men with male factor infertility, 38 were diagnosed to have oligozoospermia (<10×10⁶ spermatozoa/ml) and varicocele (10 of which were bilateral) whilst 52 men had idiopathic oligozoospermia. Ethical approval was obtained prior to commencing the study. A specimen of blood and semen was obtained from all participants. Sperm concentration, motility and morphology were assessed according to the WHO Manual (WHO, 1995). Participants were examined for the presence of a varicocele followed by an ultrasound examination of the testicles, testicular artery and vein.

The thermographic device has previously been used in rheumatology (Fraser et al., 1987; MacDonald et al., 1994) and forensic medicine (al-Alousi et al., 1994) and was shown to be reliable and reproducible (Figure 1). Measurement of testicular temperature was carried out 15 min after the removal of inguinal clothing. The room temperature was kept stable between 20 and 24°C. Examinations were carried out by two independent investigators blinded to each other’s measurements and mean values of recordings for both the scrotal neck and the lower testicular core were calculated.

The microwave detector antenna is similar in appearance to an ultrasound probe. The antenna detects microwave radiation at
neck and lower testicular pole (Figure 2). The mean value of measurements from both testes was used in the overall assessment of the participant.

In the statistical analysis, parametric data were described as mean (±SD). Unpaired t-test was used for the comparison of means. Differences between groups were analysed using $\chi^2$ test. Confidence intervals (CI) were calculated at the 95% level.

Results

All participants had a normal hormonal profile, a normal karyotype (46,XY) and negative results from cystic fibrosis screening. Demographic and clinical details of all subjects are summarized in Table I.

No difference $>$0.1°C was found between the measurements of individual observers. Scrotal neck temperatures were higher in men with varicocele compared with donors and men with idiopathic oligozoospermia. In men with unilateral varicocele, the testicular core temperatures on both testicles were raised similarly. The mean temperatures for the testicle on the same side as the varicocele [34.6°C (0.7)] was not different compared to the opposite side without varicocele [34.3°C (0.6)].

The mean testicular core temperature (of both sides), measured at the inferior testicular pole was significantly lower in donors compared with men with varicocele, and men with idiopathic oligozoospermia. The mean temperature drop from the scrotal neck to the inferior testicular pole was significantly greater ($P = 0.0001$) in donors compared with men with idiopathic oligozoospermia ($P < 0.0001$) and men with varicocele ($P < 0.001$) (Table II).

Discussion

Measurements using microwave thermography were reproducible with minimal inter-observer differences. Our findings provide further support that elevated testicular temperature has an important role in the pathophysiology of male infertility/varicocele in humans. The most interesting finding was that in men with idiopathic oligozoospermia who had no evidence of a varicocele, the testicular core temperatures were significantly raised when compared with fertile donors. This finding suggests impaired thermoregulation of the scrotum and testicles as a cause of infertility at least in some men with idiopathic oligozoospermia. It was also interesting to note that in men with unilateral varicocele the core temperatures were raised similarly in both testicles.

The microwave thermographic device senses the natural thermal radiation from the tissues of the body. Microwaves have a wavelength of ~10 cm and are therefore able to penetrate clinically useful depths of up to 4 cm directly. The tissues of the body are relatively transparent to microwave radiation at lower frequencies. These wavelengths are therefore less dependent on external conditions and travel further in tissue so that their detection at the skin surface reflects true core temperature.

Previous human studies of varicocele and its effect on testicular temperature have generally used indirect methods to estimate intratesticular temperature, including infrared scrotal thermography (Kormano et al., 1970; Monteyne and Comhaire, 1972).
Table I. Clinical characteristics of participants

<table>
<thead>
<tr>
<th></th>
<th>Sperm donors ($n = 20$)</th>
<th>Infertile patients ($n = 110$)</th>
<th>$P$-value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>30.6 (5.4)</td>
<td>34.5 (6.7)</td>
<td>NS (–0.6 to 8.6)</td>
</tr>
<tr>
<td>Semen concentration ($\times 10^6$/ml)</td>
<td>73.2 (41)</td>
<td>6.7 (5.3)</td>
<td>0.01 (–109.5 to –21.8)</td>
</tr>
<tr>
<td>Progressive motility (%)</td>
<td>54.7 (5.4)</td>
<td>19.4 (6.9)</td>
<td>&lt; 0.0001 (–41.8 to –28.8)</td>
</tr>
<tr>
<td>Morphology (%)</td>
<td>26.2 (5.6)</td>
<td>7.7 (2.8)</td>
<td>&lt; 0.0001 (–24.3 to –12.6)</td>
</tr>
<tr>
<td>FSH IU/l</td>
<td>5.6 (0.8)</td>
<td>5.9 (1.3)</td>
<td>0.1 (–1.2 to 6.4)</td>
</tr>
</tbody>
</table>

All values are mean (SD).
NS = not significant.

Table II. Differences in temperature measurements between the groups

<table>
<thead>
<tr>
<th></th>
<th>Donors ($n = 20$)</th>
<th>Varicocele–oligozoospermia ($n = 38$)</th>
<th>Idiopathic oligozoospermia ($n = 52$)</th>
<th>Donor versus varicocele $P$-value (95% CI)</th>
<th>Donor versus idiopathic oligozoospermia $P$-value (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrotal neck temperature (°C)</td>
<td>35.8 (0.5)</td>
<td>36.1 (0.5)</td>
<td>35.7 (0.6)</td>
<td>0.03 (0.03 to 0.7)</td>
<td>NS (–0.2 to 0.5)</td>
</tr>
<tr>
<td>Testicular core temperature (°C)</td>
<td>33.6 (0.9)</td>
<td>34.7 (0.7)</td>
<td>34.2 (0.7)</td>
<td>0.0001 (0.6 to 1.6)</td>
<td>0.0008 (–1.1 to –0.2)</td>
</tr>
<tr>
<td>Temperature difference between scrotal neck and testicular pole (°C)</td>
<td>–2.2 (0.7)</td>
<td>–1.5 (0.7)</td>
<td>–1.4 (0.5)</td>
<td>0.0007 (0.3 to 1.1)</td>
<td>0.0001 (–1.1 to –0.4)</td>
</tr>
</tbody>
</table>

All values are mean (SD).
NS = not significant.

1978; Zorgniotti et al., 1979), simple bulb thermometers (Zorgniotti and MacLeod, 1973), and contact scrotal thermography (Lewis and Harrison, 1980). These methods only measure the scrotal skin temperature and are merely indirect reflections of the actual scrotal temperature with no direct assessment of the temperature in the testicular core. Studies with direct methods where sensitive needle thermistors were used proved impractical (Lewis and Harrison, 1980; Kurz and Goldstein, 1986). It was concluded that contact scrotal thermography provides a means for detecting relative differences in temperatures within the testes, but that absolute temperatures, as determined by thermistor probes, are ~5% lower. The data do not indicate that this difference is constant, and a simple correction factor cannot be used to compare the two methods of determining intratesticular temperature. Variable effects of environment can make scrotal skin temperature unreliable in the assessment of testicular temperature (Agger, 1971).

In conclusion, microwave testicular thermography for the assessment of testicular core temperatures is a new technique that is safe and reproducible. The equipment described is portable. Preliminary results show altered testicular thermo-regulation in a group of patients with impaired spermatogenesis. Testicular temperature profiles obtained by microwave thermography may be of value in the assessment of infertile men with or without a varicocele.

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References


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