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ORIGINAL PAPER

Reference value of testicular temperature measured by finite element analysis after first staged inguinal orchidopexy in children with abdominal testis and short spermatic cord

Mehdi Shirazi [1, 2], Ali Eslahi [1, 3], Mohsen Ostovari [4], Faisal Ahmed [5], Ahmed Zaid [1], Mohammad Reza Askarpour [1], Hossein-Ali Nikbakht [6], Zeinab Gholami [7], Sania Shirazi [8]

[1] Department of Urology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran;
[2] Histomorphomettery and Stereology Research Center, Shiraz University of Medical Sciences, Shiraz, Iran;
[3] Shiraz Geriatric Research Center, Shiraz University of Medical Sciences, Shiraz, Iran;
[4] Department of Medical Physics and Biomedical Engineering, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran;
[5] Department of Urology, School of Medicine, Ibb University, Ibb, Yemen;
[6] Social Determinants of Health Research Center, Department of Biostatics and Epidemiology, Faculty of Medicine, Babol University of Medical Sciences, Babol, Iran;
[7] Department of Radiology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran;
[8] Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran.

Summary

***Purpose:** In this study, we aimed to build a 3D reconstruction computed simulation model and to establish a regression equation for detecting the testis's temperature by its location after first staged open orchidopexy in children with abdominal undescended testis (UDT) and short spermatic cords.*

***Methods:** In this cross-sectional study, we enrolled 31 children with abdominal UDT and short spermatic cords who underwent first staged orchiopexy between 2017 and 2020. Using ultrasonography to obtain the testis's location distance from the skin surface (X_1), external iliac vessel (X_2), and internal inguinal ring (X_3), we input the data into a 3D reconstruction computed simulation along with COMSOL to calculate the testicular temperature. We also used multivariate regression to establish the testicular temperature regression equation from the gathered data.*

***Result:** The mean age of the participants was 4.47 ± 1.21 years. The mean size of the operated testis was 0.39 ± 0.13 cc. The mean distance of the testis from X_1, X_2, and X_3 was 3.27 ± 1.25 mm, 21.06 ± 6.42 mm, and 27.19 ± 10.09 mm, respectively. The testicular temperature regression equation derived from testis location was calculated by the formula: $34.57 + 0.0236 X_1^2 - 0.0105 X_2 - 0.0018 X_3$. The concordance for testis temperature calculated via the computational method and regression equation was 83%.*

***Conclusions:** The current study provided a reference value for the testicular temperature of children with abdominal UDT and short spermatic cords after the first stage of orchiopexy. A testicular temperature regression equation can be established based on the testis location, which will provide relevant information for the testicular development assessment, disease diagnosis, and follow-up, and possibly determination of the time of the second stage of orchiopexy.*

KEY WORDS: *Abdominal testis; Temperature; Short spermatic cord; Finite element; Referential values; Simulation method.*

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INTRODUCTION

One of the most common birth anomalies in children is *undescended testis* (UDT), with estimates ranging from 1 to 4.6% of full-term newborn males affected by one or both testes failing to descend (1). Congenital UDT is caused by the failure of the first or second stage of testicular descent. Some theories about the causes of UDT include primary testicular hormonal dysfunction, secondary hormonal dysfunction (hypothalamic-pituitary axis deficiency or placental failure to produce chorionic gonadotropin), and anatomical defects in the mechanism of descent (2). Testicular maldevelopment in children with UDT is characterized by disturbed tubular structure, mainly by decreased germ cells and quantitative and qualitative changes in the Leydig cells. These tubular alterations are detectable from the UDT's first or second year of life (3). The histologic disturbances in the UDT might be related to the increased testicular exposure to elevated extra scrotal temperature (4).

Intra-abdominal testis with a short spermatic cord that does not allow the surgeons to place it in the scrotum represents approximately 30% of all UDT cases (5). There is no consensus regarding the best operation because of the testicular artery and vein length, which limits the distal placement of the testis into the scrotum. For these particular cases, the surgical solution proposed is first-stage superficial inguinal orchiopexy, then scrotal orchiopexy, tow-stage laparoscopic Fowler-Stephens orchiopexy, and/or autotransplantation (6).

The testis's temperature is 2 to 4°C below the core body (6). Scrotal thermoregulation serves to liberate the large amount of heat produced during spermatogenesis. Several supporting mechanisms like thin skin with abundant vascularization, numerous sweat glands, and the absence of subcutaneous fat facilitate heat exchange and maintain the testicular temperature below body temperature (7).

parameters of distance from the skin surface (X_1), distance from the iliac vessel (X_2), and distance from the internal inguinal ring (X_3), the X_1 parameter has more influence on the testicular temperature than others. In equation 1, the coefficient of X_1 is positive, so when the distance from the skin decreases, the central temperature of the testis decreases. Therefore, the most suitable position to place the testicles is the closest distance from the skin. Equation 1 also shows that between X_2 and X_3, the influence of the X_2 on the testis temperature is more dominant than X_3. The coefficients of X_2 and X_3 are negative. Therefore, the proper position is the one that is farthest from the iliac arteries and internal inguinal ring.
This study had several limitations, such as its retrospective nature, the lack of a control group, and the small sample size. Also, the testis size before surgery and contralateral intra-scrotal testis temperatures in children were not checked. We detected the heterogenicity of the testis size and age among the patients. The period between surgery and temperature checking was six months at least.
Therefore, this is just an observational report requiring validation with a large sample size and randomized criteria. Because the thermal factors involved in the heat exchange of children's environment are not all determinable, these models are valuable only when the children's thermal conditions and environment are both known or may be controlled.

Conclusions

The current study provided a reference value for the testicular temperature of boys with abdominal UDT and short spermatic cords after the first stage of orchiopexy. A testicular temperature regression equation derived from its location can be established, which will provide relevant information for the testicular development assessment, disease diagnosis, and follow-up, and possibly for deciding on the time of the second stage of orchiopexy.

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