Original paper

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Validity of measurements of testicular volume obtained by a built-in software of ultrasound systems: with formula recommended by updated guidelines as reference

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Keywords

testis, measurement, formula, ultrasound

Abstract

Aim: To investigate the validity of measurement of testicular volume acquired by a built-in software in different ultrasound systems with reference to the updated guidelines. **Materials and methods:** Archives of 1,976 patients who had undergone scrotal ultrasound evaluation were reviewed. A total of 973 patients with 1,909 testes, who had undergone ultrasound measurement of the testicular volume, were included in the study, and 1,003 patients were excluded. The age of enrolled patients ranged from 17 to 66 years (median age of 39 years). The ultrasound systems included Siemens Sonoline S2000, Philips EPIQ5, GE Logiq E9, Hitachi Aloka prosoundα7, Mindray DC-8 and Mindray Resona7. The transducers have imaging frequencies of 5–14 MHz. Validity of the measurement of testicular volume acquired by a built-in software in different ultrasound systems was assessed with reference to the formula that Volume (V) = Length (L) × Width (W) × Height (H) × 0.71, recommended by the updated guidelines, by recalculating the original numbers using a calculator. **Results:** The values obtained by the built-in software of Mindray DC-8 and Mindray Resona7 ultrasound systems and measurements recalculated on a computer were all in concordance; and the values obtained by the built-in software of Siemens Sonoline S2000, Philips EPIQ5, GE Logiq E9, and Hitachi Aloka prosoundα7 ultrasound systems and measurements recalculated on computer were all discordant. The same testicular measurements calculated with different formulas (V = L×W×H×0.71 vs. V = L×W×H×0.52) produced 26.76% difference. **Conclusion:** Values of testicular volume obtained by some ultrasound systems are not accurate with reference to the formula recommended by the updated guidelines.

Introduction

In reproductive medicine, andrology and urology, the measurement of testicular volume becomes a routine examination for infertile males, for it is generally regarded as an index representative of spermatogenesis or semen profile; in other male patients with gonadal anomalies , the measurement of testicular volume is a necessity, so accurate measurement of testicular volume is important in the evaluation of disease and may also help in determining proper treatment[1–3]. There are several methods available for the measurement of testicular volume, such as caliper, various orchidometers, medical imaging; among them, ultrasound examination is considered the most accurate[4–16]. Currently, ultrasound imaging becomes widely accessible and available, with other methods of measurement of testicular volume being almost replaced by ultrasound[7–16]. In clinical practice, the value of testicular volume is usually worked out immediately by a built-in software of an ultrasound system based on the measurements of testicular length, width and height (anteroposterior depth), and rarely implemented by manual calculation using a certain formula. Radiologists and urologists rarely suspect the quality and functions of advanced medical ultrasound systems

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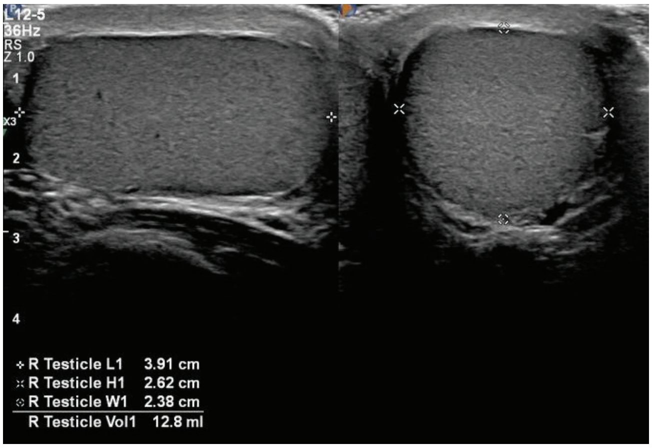

Fig. 1. *A 31 year-old man with infertility. Measurement of the right testicular volume using ultrasound. The length, width, and height of the testis are 3.91 cm, 2.62 cm, and 2.38 cm, respectively; and the testicular volume is 12.8 mL, which is obtained automatically by the Philips EPIQ5 ultrasound system with a built-in software*

produced by world's well-known corporations, and the measurement of testicular volume by a built-in software of an ultrasound system has been trusted. However, every rule has its exception. The objective of this study was to investigate the validity of measurement of testicular volume acquired by a built-in software in different ultrasound systems with reference to the updated guidelines.

Materials and methods

Archives of 1,976 patients who had undergone consecutively scrotal ultrasound evaluation in a tertiary hospital with provincial human reproductive center from January 1, 2016 to January 1, 2020 were reviewed. A total of 973 patients with 1,909 testes, who had undergone ultrasound measurement of the testicular volume were included, and 1,003 patients who had not undergone measurement of the testicular volume were excluded. The age of enrolled patients ranged from 17 to 66 years (the median age was 39 years). The measurements of each testis saved in the Picture Archiving and Communication Systems (PACS) were reviewed and *re*calculated on a built-in calculator in the computer, with the formula that Volume (V) = Length (L) × Width (W) × Height (H) × 0.71 used as a reference criterion, which has been proved to be the most accurate formula by previous studies and was recommended in Guidelines of the European Society of Urogenital Radiology Scrotal and Penile Imaging Working Group, and by the Guideline developed in collaboration with the American College of Radiology; Society for Pediatric Radiology; Society of Radiologists in Ultrasound(6–9,14–18). For validity, the original values obtained by the built-in software of ultrasound systems were compared with the *re*calculated values. Meanwhile, some of the data obtained by different ultrasound systems were also validated using a formula that V = L×W×H×0.52(7,9,10,17,18). The protocols for the scrotal assessment of ultrasound were addressed in the following manner. The patient was examined in a supine recumbent position, after proper exposure of the scrotum, adequate volume of couple gel was placed onto the scrotum; a linear-array transducer was used to scan the scrotum and multiple parameters were assessed, including testicular volume (size), anatomic variants, and abnormalities of the testes, epididymides, tunica vaginalis and scrotal wall. Color Doppler flow imaging and pulsed wave Doppler assessment were performed as an integral part of the examination to evaluate vasculature in the testis and the spermatic cord. The transducer was placed on the scrotum without exerting pressure on the testis, and optimal dimensions were rendered to measure length, width and height (anteroposterior depth) of the testis. The linear-array transducers equipped in different ultrasound systems have imaging frequencies of 5–14 MHz. For each examination, the examination mode was preset to "small parts and testis"; parameters of gain, depth gain compensate, focus, depth, and scale were adjusted to an adequate status; the testicular volume was calculated automatically by the built-in software of the ultrasound system based on the measurement of the testicular length, width, and height. Fig. 1 illustrates the measurement of testicular volume. Images of duplex ultrasound imaging with and without measurements were saved in the PACS. The ultrasound systems used during this period included Siemens Acuson S2000 (Siemens Medical Systems, Inc., Ultrasound Group, Mountain View, California, USA); Philips EPIQ5 (Philips Ultrasound, Inc., Bothell, Washington, USA); GE Logiq E9 (GE Healthcare, Waukesha, WI, USA); Mindray DC-8 (Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China); Mindray Resona 7 (Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China); Hitachi-Aloka prosoundα7 (Hitachi Aloka Medical Systems, Tokyo, Japan). Distribution of testicular volume measurements performed by different ultrasound systems was allotted.

Ethical statements

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the World Medical Association Declaration of Helsinki (revised in 2000). The study was approved by the institutional review board of The First Affiliated Hospital of Hainan Medical University, and informed consent was waived due to the retrospective design.

Results

Distribution of testicular measurements by different ultrasound systems and outcome of validity were listed in Tab. 1. Taking the formula that V = L×W×H×0.71 as the standard criterion, the values obtained by the built-in software of Mindray DC-8 and Mindray Resona 7 ultrasound systems and measurements recalculated on a computer were all concordant, and the values obtained by the built-in software of Siemens Acuson S2000, Philips EPIQ5, GE Logiq E9, and Hitachi Aloka prosoundα7 ultrasound systems

Tab. 1. *Comparison of values obtained by the built-in software of ultrasound systems and re-calculated values with reference to the updated guidelines*

Ultrasound systems	Manufacture date	Software update date	Distribution of testicular measurement (*n* = 1909)	Concordance after validity (*n* = 566)	Discordance after validity (*n* = 1343)
Siemens Acuson S2000	September 2009	July 2015	352	0	352
Philips EPIQ5	February 2018	No	224	0	224
GE Logiq E9	March 2017	No	362	0	362
Mindray DC-8	June 2012	January 2017	363	363	0
Mindray Resona 7	November 2017	No	203	203	0
Hitachi Aloka Prosound α7	October 2010	No	505	0	505

and measurements recalculated on computer were all discordant. The overall conformity rate was 29.65%. If the formula that V=L×W×H×0.52 was used as the standard criterion, the above results of concordance and discordance for value comparison reversed. The same testicular measurements calculated with different formulas (V = L×W×H×0.71 vs. V = L×W×H×0.52) produced 26.76% difference in the value of testicular volume.

Discussion

Before promulgation of the guidelines and recommendations for the use of formula V = L×W×H×0.71 for the testicular volume measurement in 2020, many studies had shown that the formula V = L×W×H×0.71 is more accurate since 2000; however, some manufactures of ultrasound imaging systems had not adopted it[6–10,14–17]. In our study population, the overall conformity rate was 29.65%, the data acquired by some ultrasound systems do not meet the value calculated with reference to the formula by the updated guidelines. The values of testicular volume obtained by the formulas adopted by different ultrasound systems caused a discrepancy of 26.76%. While they are concordant with the value calculated according to the formula that V = L×W×H×0.52. Obviously, some of the ultrasound systems had adopted formula V = L×W×H×0.52, other than V = L×W×H×0.71.We believe that the reason is that some manufactures have not adopted the updated research result, and failed to update the related parameters or the formula. The discrepancy of 26.76% is detrimental in some cases, leading to an incorrect interpretation and a subsequent bias. For example, if two testicular volumes obtained by an ultrasound system with a built-in formula that V = L×W×H×0.52 are 26.3 mL (13.0 mL and 13.3 mL, respectively), the urologist will determine that the two testes are not in normal size, with reference that the low size of a normal testis is 14 mL, and both are 28 mL (these references were obtained according to the formula that V = L×W×H×0.71). However, according to the latest guidelines, the testicular volumes should be 33.34 mL (16.48 mL and 16.86 mL, respectively), so these values meet the normal criteria.

During the previous studies on the measurement of testicular volume, several formulas have been invented, such as V = L×W×H×.52, V = L×W(2)×0.52, V = L×W(2)×0.59, and V = L×W×H×0.71; among them, V = L×W×H × 0.71 has been proved the most accurate[6–10,14–17]. Bahk *et al*., and Takihara *et al*. reported that the normal range of adult testicular volume (calculated by V = L×W×H×0.71) was greater than 14 mL in Japan, greater than 17 mL in the United States, and around 18 mL in the South Korea[2,5]. There is still no official reference for normal testicular size, but accurate assessment is significant for an infertile male. Studies have shown that the testis size varies with racial, regional, body weight, height, and nourishment conditions[5,18]. Therefore, comprehensive evaluation combining the measurement of testicular volume with other parameters may be more reasonable in the clinical practice of reproductive medicine[5,18,19].

The limitations of this study are that only six ultrasound systems by five manufactures were investigated, and the sample was small.

The findings of this study suggest that the manufacturers of ultrasound imaging systems should update related parameters in time, and the sonographers, radiologists, and urologists should be aware of the fact that some ultrasound systems have not adopted the proper formula for the assessment of testicular volume, which produces discrepancy in clinical practice, and the testicular volume needs to be calculated using a more reliable updated formula.

Conclusion

In conclusion, the values of testicular volume obtained by some ultrasound systems are not accurate according to the formula recommended by the updated guidelines. Sonographers, radiologists and urologists should validate the testicular volume with reference to the original measurements and the updated formula.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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