434

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WHAT IS THE REAL ACCURACY OF ULTRASOUND MEASUREMENTS ?

Hypothesis / aims of study

Ultrasound is a very important imaging method for the assessment of the lower urinary tract. However, different investigators use different parameters for assessment purposes. The most accurate ultrasound assessment of the lower urinary tract is based on the use of x,y coordinates in the orthogonal system in accordance with the guidelines of the ICS and the recommendation of the German Urogynecology Working group. But direct measurements of x,y coordinates during ultrasound examination is highly complicated. The aim of our study was to asses the effect of the operator on the measurement (the operator's measurement error), the effect of experience on measurement (a comparison between an experienced ultrasound operator (1) and young trainees (operator 2)), the validity of the measurement (the accuracy of the measurement of the same parameter, using simple parameters for the assessment of the mobility of the bladder neck.

Study design, materials and methods

The position of any point in the plane can be expressed in eiher orthogonal (x, y) or polar (p,□) coordinates. We chose the latter ones as they are easier to measure during an ultrasound examination (most ultrasound machines allow measurement of the distance and angle). The orthogonal coordinates (x,y) can be then easily calculated form p and □̃
50 women were included in the study. The coordinate system was defined as follows: the x axis is the axis of the symphysis, with 0 at lower edge of the symphysis. The y axis is perpendicular to x. In this system the rotational angle gama (□) and distance (p) between the lower edge of the symphysis (origin of the system) and bladder neck were measured. The measurements were taken at rest and during maximal Valsalva, repeated independently twice by each observer (for each measurement the probe was placed to the perineum).
Reliability of measurements was tested via F-test in mixed model ANOVA. First the work of the two operators was examined separately, with only the measurement number as a fixed factor and ID number of a patient as random factor. Next, the effect of the operator was included in the model, in nested design, with operator as fixed effect, measurement nested in operator as fixed effect and patient ID as random effect.
The measures of reliability used are retest correlation expressed as Pearson correlation coefficient (R) or intraclass correlation coefficient (ICC) where appropriate; absolute typical error and typical error expressed as coefficient of variation (CV).
Statistical software STATISTICA 6.0 (StatSoft. Inc.) was used throughout the analysis.

Results

The measurement on one subject by the first operator is consistent at rest and at maximal Valsalva (Tab. 1). With Operator 2 the variability of the measurement is higher, the measurements at rest show significant differences while the measurements at maximal Valsalva are more consistent (Tab. 1). Operator 2 has statistically significant higher error namely in measurement of the distance p. The vector of movement (distance between the position of the point at rest and at maximal Valsalva) shows a typical error of 2.2 and 2.4 mm for Operator 1 and 2 respectively. The change of the position of the bladder neck between the first and second measurement of each operator was also compared. For Operator 1 the shift was 2.1 $\pm$ 1.5; for Operator 2 3.3 $\pm$ 1.7 (differences between operators are statistically significant). Differences at maximal Valsalva were similar.
While the variability in measuremets is similar for both operators, this does not mean that final measurements are the same. The data from both operators are statistically different in virtually all parameters, with the exception the vector of the movement. Variability of parameters is 1.5 higher than if measured by only one operator. Again the vector of the movement is not influenced by the variability of the measured parameters.

Interpretation of results

Differences between the operators are probably due to different placement of the axis of the symphysis, as there are minimal differences in vector of movement (independent of the placement of the axis) while there are important changes in absolute position. Experience decreased the measurement error. Statistical evaluation indicates that the differences between the operators are statistically significant. The question is whether these differences are clinically significant.

Concluding implication

The mobility vector is least influenced by the operator than the absolute measurements.
To compare different investigators it is better to compare changes of the vector of movement than absolute measurements of the parameters.

Tab. 1

First operator. comparsion of two measurements				Second operator. comparsion of two measurements				Mean of the comparisons 1+3.1+4.2+3.2+4		
Pearson corr. coefficient R	rest	Vals.		**Pearson corr. coefficient R**	rest	Vals.		**Pearson corr. coefficient R**	rest	Vals.
gamma	0.94	0.95		gamma	0.92	0.94		gamma	0.84	0.82
p	0.95	0.90		p	0.87	0.91		p	0.82	0.81
x	0.95	0.96		x	0.92	0.95		x	0.85	0.87
y	0.90	0.90		y	0.83	0.91		y	0.79	0.73
vector		0.89		vector		0.88		vector		0.69
Typical error of measur.	rest	Vals.		**Typical error of measur.**	rest	Vals.		**Typical error of measur.**	rest	Vals.
gamma [degrees]	3.58	6.23		gamma [degrees]	4.61	8.06		gamma [degrees]	6.32	12.80
p [mm]	0.95	1.45		p [mm]	1.65	1.30		p [mm]	1.91	1.92
x [mm]	1.40	1.65		x [mm]	1.95	1.91		x [mm]	2.62	2.90
y [mm]	1.16	1.54		*y* [mm]	1.64	1.73		*y* [mm]	1.75	2.77
vector [mm]		2.23		vector [mm]		2.41		vector [mm]		3.81
efect of the measur. (p-value)	rest	Vals.		**efect of the measur. (p-value)**	rest	Vals.		**efect of the operator(p-value)**	rest	Vals.
gamma	0.8411	0.3421		gamma	0.2503	0.4125		gamma	<0.0001	0.0040
p	0.0682	0.3706		p	0.0292	0.8842		p	<0.0001	0.7134
x	0.8700	0.2600		x	0.5256	0.3523		x	<0.0001	0.0309
y	0.1489	0.9235		y	0.0051	0.9802		y	0.0010	0.0099
vector		0.1909		vector		0.8511		vector		0.0784

Tab. 2

Hierarchical model – exact results										
	Operator 1				Operator 2			**Total**		
Efect of the measur. (p-value)	rest	Vals.		**Efect of the measur. (p-value)**	rest	Vals.		**Efect of the measur. (p-value)**	rest	Vals.
gamma	0.89	0.59		gamma	0.35	0.63		gamma	0.63	0.7755
p	0.31	0.45		p	0.03	0.85		p	0.06	0.7462
x	0.92	0.46		x	0.59	0.51		x	0.86	0.6250
y	0.30	0.95		y	0.004	0.82		y	0.009	0.9753
vector		0.38		vector		0.92		vector		0.6820
ICC-intraclass correlation								**Total**		
ICC (retest correlation)	rest	Vals.		**Typical error of measurement**	rest	Vals.		**efect of the oper. (p-value)**	rest	Vals.
gamma	0.86	0.86		gamma [degrees]	5.70	11.26		gamma	<0.0001	0.0040
p	0.84	0.84		p [mm]	1.74	1.76		p	<0.0001	0.7134
x	0.88	0.90		x [mm]	2.36	2.59		x	<0.0001	0.0309
y	0.81	0.78		*y* [mm]	1.65	2.46		y	0.0010	0.0099
vector		0.75		vector [mm]		3.40		vector		0.0784

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