Systematic analysis of physical rhinological function tests

Klaus Vogt /Germany and Latvia

Klaus – Dieter Wernecke/ Germany

Rudolf Viksne/Latvia

Sindija Gutmane/Latvia

Anita Bergmane/Latvia

Why do we need a systematic analysis of nasal function tests ?

- The introduction of physically based nasal function tests into the clinical practice started about 50 years ago by COTTLE (head-out-plethysmograph) and MASING (rhinomanometry). After the introduction of computer aided rhinomanometry (Vogt&Wernecke, J.Pallanch, E.B.Kern) it was necessary to create international standards. The International Standardization Committee for the Objective Assessment of the Upper Airways (ISCOANA) was established in 1983 by the International Rhinologic Society as a consortium of medical doctors
- After the standard of 1984 no progress according to new techniques was considered or published
- A standard in function tests has to be created by physicists, technicians, statisticians AND physicians!

Riga 2016 – a new begin

- By invitation of the University of Latvia a group of experts in aerodynamics, mathematicians,physicists and engineers and clinical rhinologists resumed the state of art in functional rhinology and created new standard, which was published in 2018

K. Vogt - G. Bachmann-Harildstad - A. Lintermann - A. Nechyporenko - F. Peters - K.D. Wernecke

The new agreement of the international RIGA consensus conference on nasal airway function tests

Rhinology 56-2: 133-143, 2018

- The participants of the conference started together with the German SMEs MedContact and Sutter the Rhinodiagnost-program supported by the Austrian and German Government

The aim: Evidence Based Medicine (EBM)

Evidence based medicine is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients.

The practice of EBM means the integration of individual clinical expertice with best possible external evidence from systematic research.

Sackett, D.L., Rosenberg, W.M., Haynes, R.B., Richardson, W.S. (1996): Evidence based medicine: what it is and what it isn't. BMJ, 1996, Jan 13; 312(7023); 71-2

METHODS for the functional evaluation of the nasal air stream

- Active Anterior Rhinomanometry
- Determination of total nasal resistance by measurements and calculation
- Peak Nasal Inspiratory Flow PNIF
- Acoustic rhinometry
- Optical rhinometry
- Rhinostereometry
- Long term measurements
- Odiosoft
- Nasometry

Indirect measurements or estimations with limited diagnostic power

Measurement Capability

The usefulness of a diagnostic measuring device depends on the

- **Repeatability** (several measurements by the same investigator) and the
- **Reproducibility** (several measurements of the same patient by different investigators).

While the technical reliability can be registered by models and simulators, reproducibility and repeatability have to be examined in clinical tests and approved by statistical methodology.

Measurement Capability

This includes in particular:

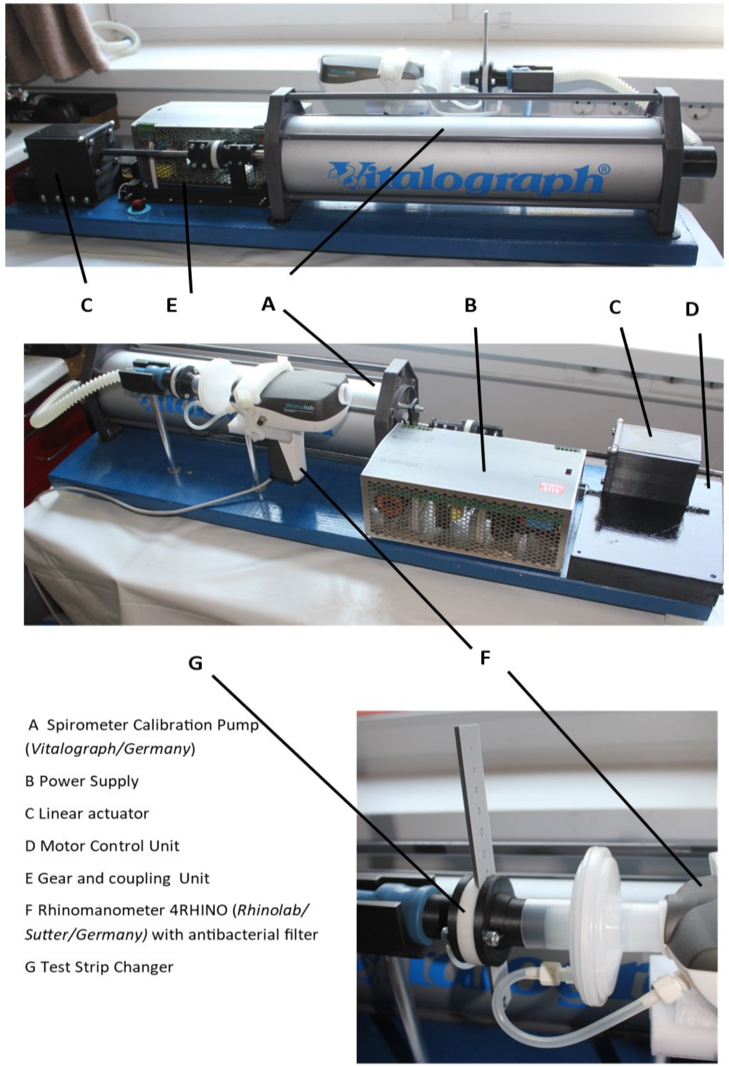
- Precision and accuracy of measurements as given by technical equipment and/or
- Software details (evaluating gauge repeatability and reproducibility),
- Total variability of the given process,
- Intra-individual variability,
- Inter-individual variability,
- Statistical analyses by using two-way analyses of variance,
- Arguable agreement with other methods of measuring,
- Comparability under different clinical conditions.

Measurement Capability: Results

- 4-Phase-Rhinomanometry is reliable and delivers correct parameters
- The analysis of the total process variability by using two-way analysis of variance (ANOVA) resulted in significant repeatability and reproducibility of 4-Phase-Rhinomanometry
- PNIF is very good reproducible but delivers physical and physiological nonsens because of restricting any information about the physiology of the nasal valve

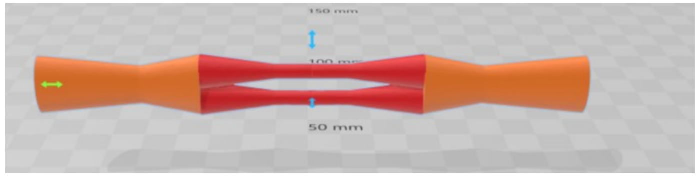
Simulation of the nasal airstream as tool for reproducibility and quality management

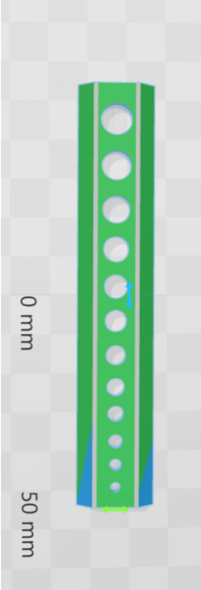
- Since 1989, i.e.during the development of the rhinomanometers CARIMA,HRR 2,HRR3 and 4RHINO also simulators for the visualisation of the nasal air stream have been developed by us and demonstrated on different meetings. The analysis of different typical cavities lead to the creation of types in rhinomanometry
- Contemporary step motors and linear actuators can be used to set up precisely working pumps which are digitally controlled by appropriate programs. These techniques are integrated in the „Artificial Noses“ ARNO 4 and ARNO 5.



Application of simulators

- Controlling the measurement results of different rhinomanometers and correction of the calibration if necessary under dynamic conditions
- Simulating the nasal air stream through different streaming bodies comparable to the anatomy of the nose
- Generating reproducable flux to check the dependency of pressure and flow from shape, length and diameter of the streaming body

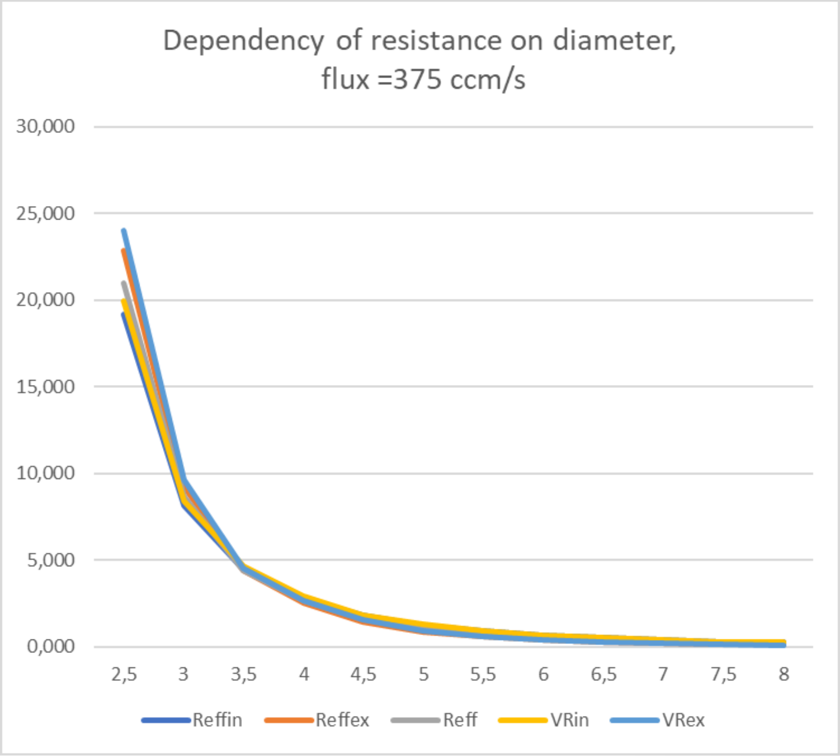


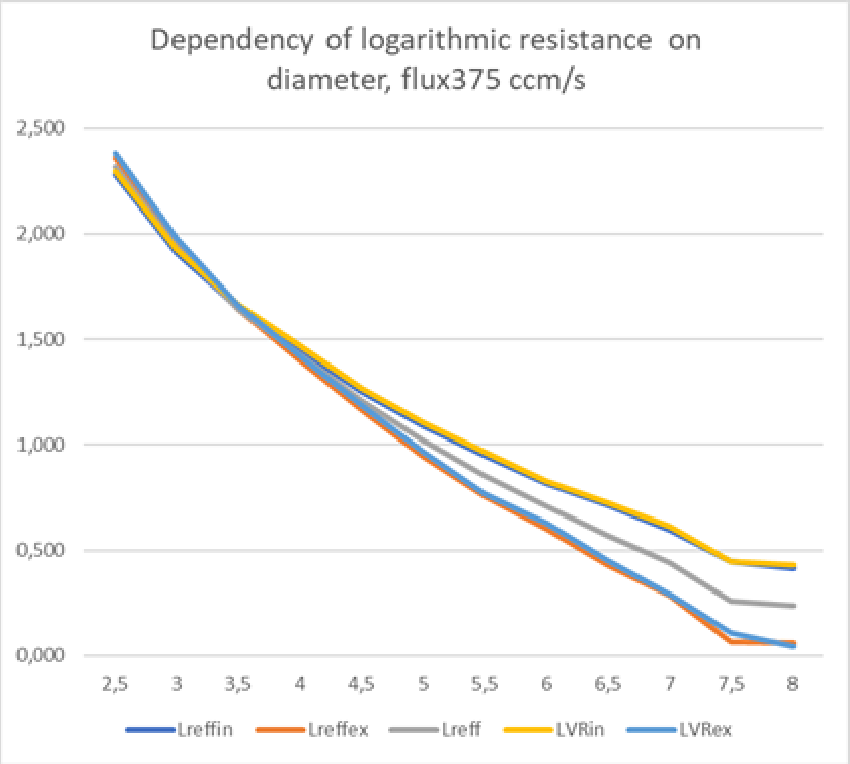


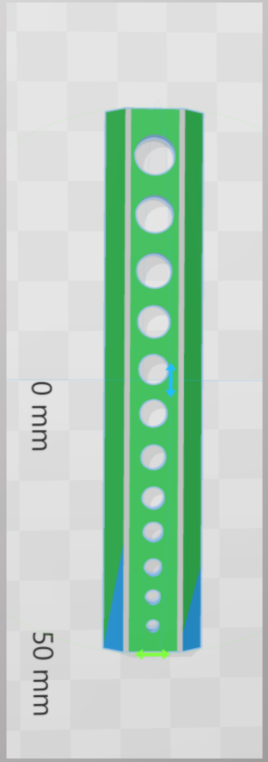
Simulation of different breathing types in 4 different rhinomanometers of the same series

Abweichungen rhinomanometrischer Messungen von 4 Seriengeräten Typ 4RHINO										
	Atemtyp Sinus									
	LreffIn	*Lreffex*	*Lreff*	*LVrin*	*LVrex*	*ReffIn*	*ReffEx*	*Reff*	*Vrin*	*Vrex*
Mittelwert	0,95	0,90	0,93	0,96	0,93	0,89	0,80	0,85	0,94	0,87
Standardabweichung	0,02	0,02	0,02	0,03	0,02	0,04	0,03	0,03	0,06	0,04
Anzahl	46	46	46	34	34	46	46	46	46	46
Standardabweichung % Mittelwert	**1,91**	**1,67**	**1,79**	**3,63**	**2,66**	**4,11**	**3,43**	**3,77**	**6,15**	**4,80**
	Atemtyp Trapezoid									
	Lreffin	*Lreffex*	*Lreff*	*LVRin*	*LVRex*	*Reffin*	*Reffex*	*Reff*	*Vrin*	*Vrex*
Mittelwert	1,04	0,98	1,01	1,03	0,96	1,10	0,96	1,03	1,08	0,91
Standardabweichung	0,05	-0,32	-0,01	0,26	0,24	0,07	-0,31	0,00	0,46	0,42
Anzahl	48	48	48	48	48	48	48	48	48	48
Standarddeviation % Mittelwert	**5,21**	**-33,06**	**-1,19**	**25,09**	**24,94**	**6,40**	**-32,27**	**0,38**	**42,32**	**45,89**

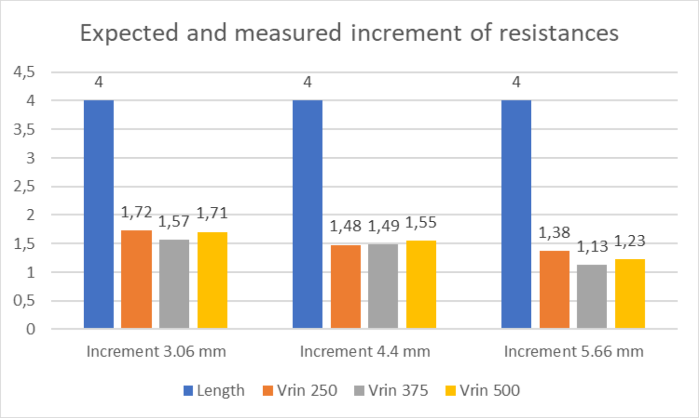
Testing resistance parameters depending on diameters and flux in holes

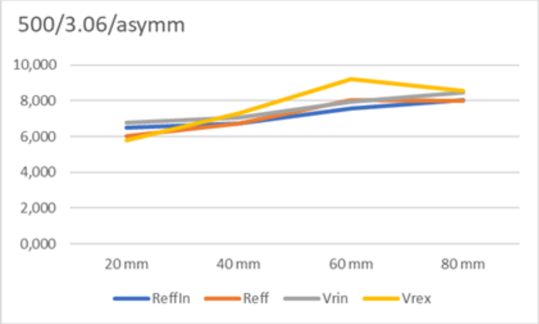


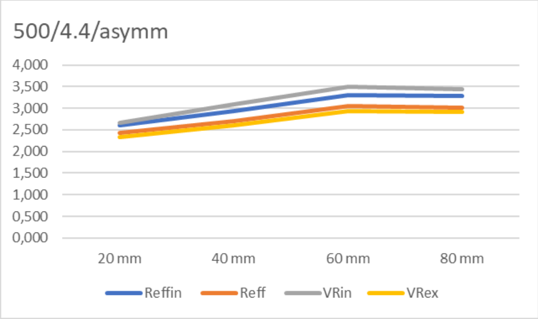


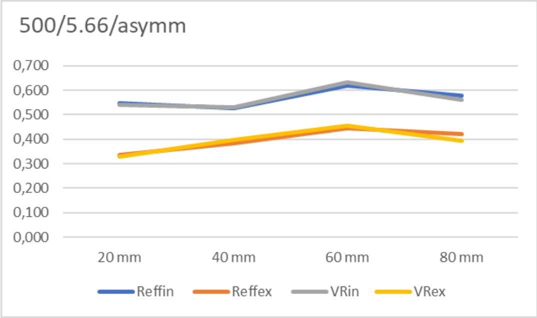


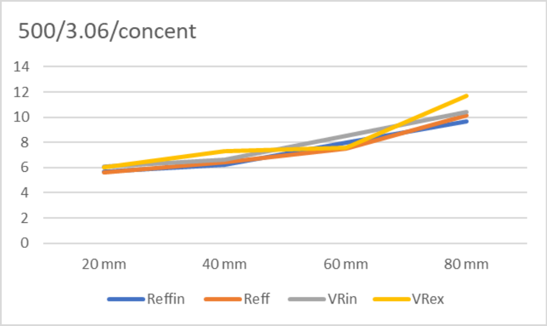
Dependency of resistances on length

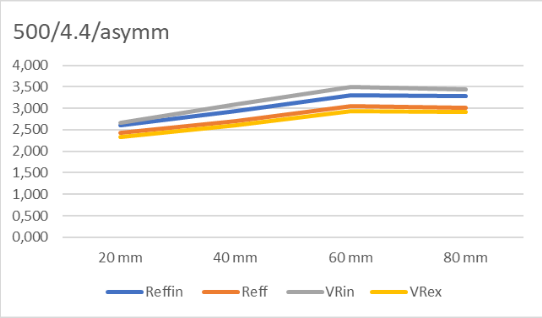


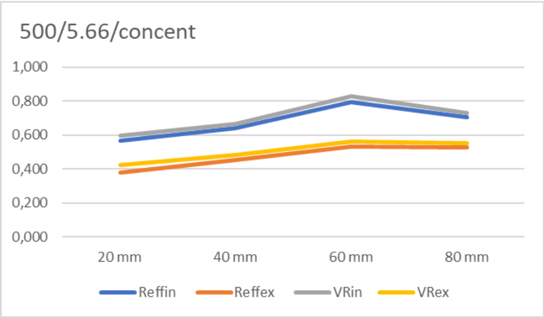










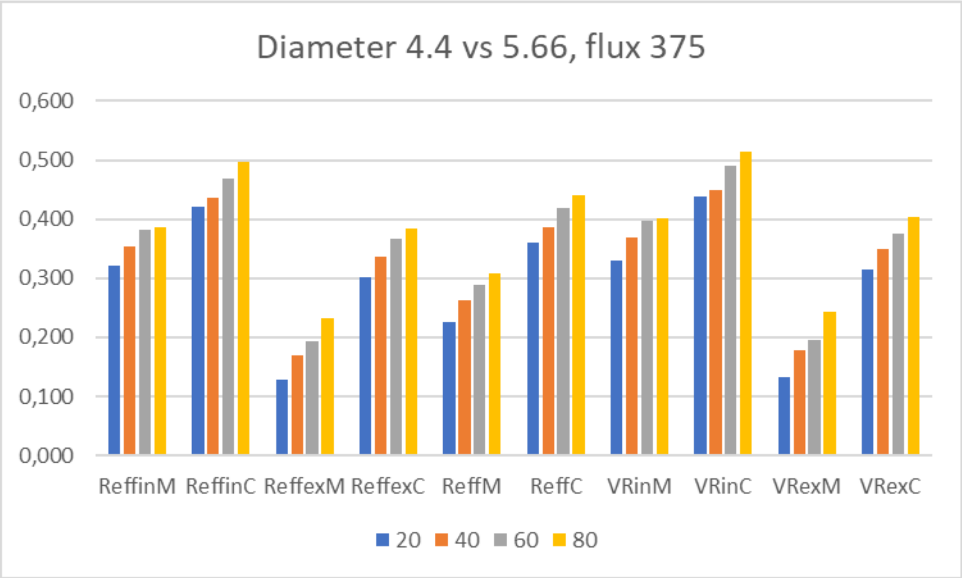


The increment of resistance in short tubes is NOT following HAGEN-POISEUILLE´s law !!

Testing the validity of KIRCHHOFF´s rule for the estimation of bilateral resistances

$$R_{Tot} = \frac{R_{right}\, R_{left}}{R_{right} + R_{left}}$$

Differences % of measured bilateral data				
Reffin	Reffex	Reff	VRin	VRex
52,3	63,3	57,4	54,2	66,5
48,9	54,4	51,3	48,1	50,5
55,6	68,4	61,2	58,6	68,6
39,0	52,7	45,3	43,7	58,5
37,7	135,2	67,7	39,6	136,2
43,5	109,1	66,2	46,8	112,9
42,3	108,4	64,9	44,9	106,4
46,9	120,2	72,2	49,0	126,0
30,7	135,0	60,4	32,9	135,2
23,0	97,2	47,2	21,7	95,6
22,7	89,7	45,4	23,9	91,6
28,7	65,7	42,6	28,2	66,0



The equation for the calculation of parallel electric resistances is not applicable for the total nasal airway resistance !!