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VARIATION OF RECORDED NOISE WITH DISTANCE FROM AN OBSTRUCTION IN A POLYVINYL ALCOHOL MODEL OF THE URETHRA.

Aims of study

The most widely accepted method for diagnosing Bladder Outlet Obstruction (BOO) is the invasive pressure-flow study. Recently non-invasive methods for diagnosing BOO have been introduced. One of these methods is perineal noise recording. Noise may be caused by turbulence downstream of an obstruction of the urethra by e.g. an enlarged prostate and can be recorded at the perineum. The characteristics of the recorded noise vary among others with the distance from the obstruction [1, 2]. To explore the feasibility of perineal noise recording in assessing the degree of an obstruction, we have studied the relation between noise recordings and the distance from the obstruction in a flexible and extensible model of the urethra at different degrees of obstruction. We applied five degrees of obstruction and recorded the noise at nine distances from the obstruction.

Materials and methods

We made a model of the urethra by freezing and thawing an aqueous solution of the polymer Polyvinyl Alcohol (PVA) in a mould [1]. The model had an outer diameter of 16 mm, a Y-shaped channel and was freeze-thawed twice. It was placed in a self-made container filled with water. One side was connected to a water column representing bladder pressure. The other side was connected to an outflow tube. To create a controlled obstruction an inflatable cuff, controlled by a second water column, was placed around the model. We applied five degrees of obstruction by controlling the pressure in the cuff and adjusting the bladder pressure, resulting in five combinations of three bladder pressures and three flow rates (see Table 1). For comparison we calculated and included values of the Bladder Outlet Obstruction Index (BOOI) [3]. We measured the flow rate with either a turbine flow meter (obstruction level 1, 2, 3 and 5) or a Dantec© rotating disk flow meter (obstruction level 4). Noise was recorded at 2, 3, 4, …, 10 cm from the midpoint of the cuff and each recording was repeated five times. The produced noise was amplified a 100 times (at obstruction level 3 the noise was amplified 10 times) and band-pass filtered between 50-5000 Hz. The filtered signal was sampled at a rate of 10 kHz and stored on a PC. We selected 2^{19} samples (~50 sec.) from each recording. We normalised each recording by dividing the signal amplitude values by the average amplitude value and calculated the power spectrum of this normalised signal by fast Fourier transformation after applying a Hanning window of 2^{19} samples. Subsequently the power in the frequency band between 350 Hz and 750 Hz was calculated. Both the power at each distance and the position of the maximum were averaged over the five repetitions at each degree of obstruction. The average positions of the maximum at the five degrees of obstruction were statistically tested using a Bonferroni t-test. The differences between powers in the specific frequency band at the different distances from each obstruction were statistically tested using Analysis of Variance.

Table 1: Bladder pressure, flow rate and Bladder Outlet Obstruction Index of the five degrees of obstruction applied

Obstruction Level	Bladder pressure (cm H_2O)	Flow rate (ml/s)	Bladder Outlet Obstruction Index (BOOI)
5	145	8	129
4	145	13.5	118
3	110	10.5	89
2	80	8	64
1	80	13.5	53

Results

The average position of the maximum power was not significantly different between the five degrees of obstruction; therefore the power at each distance from the obstruction was averaged over the five degrees of obstruction (see Figure 1). There was a significant difference ($p < .01$) between the power at the different locations of recording.

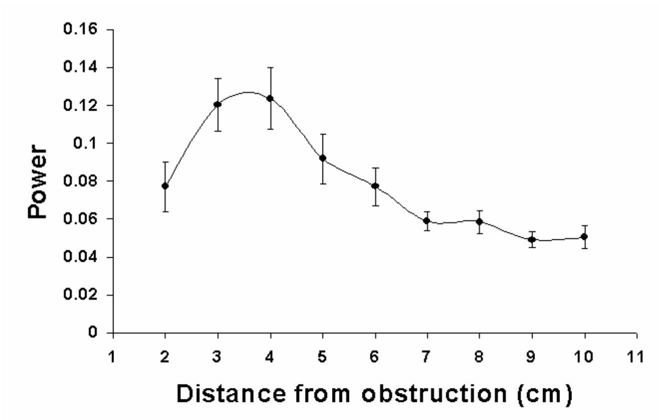

Figure 1: Average power (± s.e.m.) in the frequency band 350 – 750 Hz averaged over five degrees of obstruction.

Interpretation of results

We have applied five degrees of obstruction and recorded noise at 9 distances from the obstruction. With increasing distance, the power in the frequency band 350 – 750 Hz appears to increase to a maximum and than to decrease at each of the applied degrees of obstruction. This relation found in our PVA model urethra is in good agreement with the relation found in a silicone model [2], although at a different length scale. The significant difference in power measured at different distances from the obstruction in our PVA model urethra indicates a significant change in the shape of the power spectrum with increasing distance from the obstruction. Therefore, from a perineal noise recording at more than one location it might be possible not only to assess the degree of obstruction, as we have shown before [1], but also to assess the location of the urethral obstruction.

Concluding message

The power in the frequency band 350 – 750 Hz of a noise recording in a PVA model of the urethra varies with the distance between the microphone position and the obstruction. In general, upon moving the microphone downstream from the obstruction the power appears to increase to a maximum and than to decrease irrespective of the degree of obstruction. This significant change in the shape of the power spectrum suggests that for a clinical application noise should be recorded at more than one location at the perineum.

References

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