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MATERIALS

The international scientific-practical conference

« INTEGRATION OF SCIENCE, EDUCATION AND INDUSTRY: GLOBAL CHALLENGES, INNOVATIVE SOLUTIONS AND SUSTAINABLE DEVELOPMENT»

Tashkent, London
August 3, 2026

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Integration of science, education and industry: global challenges, innovative solutions and sustainable development // Materials International Scientific-Practical Conference. Tashkent-London. August 3, 2026.

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The event aims to discuss contemporary research across various scientific fields, exchange new scientific ideas, and support scientific activities aligned with global innovative processes.

Within the conference framework, scientists, researchers, young scholars, and practicing specialists will have the opportunity to present their research findings, exchange scientific ideas, and expand international collaboration.

The main objective of this International Scientific-Practical Conference is to consolidate the results of contemporary research across various scientific fields and strengthen the integration of science and practice through advanced scientific approaches.

**The authors are responsible for the content of the articles, the information, facts, and figures presented therein.*

The proceedings of the International Scientific-Practical Conference have been discussed by the Scientific-Technical Council of the international publisher **„Academic Research Publisher"** (London, United Kingdom) and recommended for publication (August 1, 2026, Protocol No. 28).

8. MEDICINE, PHARMACY AND MODERN HEALTHCARE TECHNOLOGIES

AN ALLOMETRIC POWER-LAW FORM OF THE PRESSURE–FLOW RELATION IN PAEDIATRIC BLADDER OUTLET OBSTRUCTION

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Introduction

Clinical indices of bladder outlet obstruction assume a fixed functional form for the dependence of urine flow on outlet geometry and driving pressure. The Abrams–Griffiths construction is linear in pressure; hydrodynamic reasoning suggests either an orifice law, in which flow scales with the square root of pressure, or a Poiseuille law, in which it scales linearly with pressure and quadratically with cross-sectional area. Which of these governs the paediatric urethra during micturition has not been established empirically. We estimate the exponents directly rather than assuming them.

Model and method

Let Q denote mean flow rate, S_u the effective urethral cross-sectional area and p_{det} the intravesical voiding pressure. We postulate the allometric form

$$Q = k \cdot {S_u}^{\alpha} \cdot {p_{det}}^{\beta}, \quad (1)$$

in which k is a dimensional constant and the exponents α and β are to be estimated. Two limiting cases follow from first principles. Discharge through a short orifice obeys the Bernoulli relation

$$Q = C_d \cdot S_u \cdot \sqrt{2\,g\,h}, \quad so \quad \alpha = 1,\ \beta = 1/2, \tag{2}$$

whereas fully developed laminar flow in a long tube obeys the Hagen–Poiseuille relation

$$Q = \frac{\pi\, r^4\, \Delta p}{8\,\mu\, L} = \frac{{S_u}^2\, \Delta p}{8\,\pi\,\mu\, L}, \quad so \quad \alpha = 2,\ \beta = 1. \tag{3}$$

Taking logarithms of (1) linearises the model in its parameters,

$$ln\, Q = ln\, k + \alpha \cdot ln\, S_u + \beta \cdot ln\, p_{det} + \varepsilon\,, \tag{4}$$

so that ordinary least squares applies. With the design matrix X collecting a unit column and the two logarithmic regressors, and y the vector of ln Q, the estimator and its covariance are

$$\hat{b} = (X^T X)^{-1} X^T\, y\,, \quad Var(\hat{b}) = s^2 (X^T X)^{-1}\,, \tag{5}$$

$$s^2 = \frac{1}{n-k} \sum_{i=1}^{n} \left(y_i - \hat{y}_i\right)^2 . \tag{6}$$

Agreement with each limiting case is tested by the Student statistic

$$t = \frac{\hat{\alpha} - \alpha_0}{SE(\hat{\alpha})}\,, \quad df = n - k\,, \tag{7}$$

with α_0 = 1 for the orifice law and α_0 = 2 for the Poiseuille law, and correspondingly β_0 = 1/2 and β_0 = 1.

Material

Group mean values of Q, S_u and p_{det} were taken from a cohort of 142 boys operated on for posterior urethral valves by three techniques — endoscopic valve resection (n = 32), polyethylene valvulotome ablation (n = 49) and metallic valvulotome ablation (n

= 61) — each measured before and after operation, giving n = 6 observations in the state space of (1) and k = 3 estimated parameters.

Results

Least-squares estimation of (4) gave ln k = −2.142, $\hat{\alpha}$ = 0.599 (SE 0.326) and $\hat{\beta}$ = 1.360 (SE 0.593), with R^2 = 0.987, adjusted R^2 = 0.979 and $F(2, 3) = 117.1$ ($p = 0.0014$). The residual standard deviation on the logarithmic scale was 0.049, corresponding to a typical prediction error of about 5 % on the natural scale (Table 1).

Table 1. Observed and fitted mean flow rates

State	S_u, cm²	p_{det}, cmH_2O	Q observed, ml/s	Q fitted, ml/s
I, preoperative	0.30	34.91	6.98	7.15
I, postoperative	0.47	43.73	13.42	12.70
II, preoperative	0.30	37.36	8.17	7.84
II, postoperative	0.47	44.79	12.67	13.12
III, preoperative	0.31	36.31	7.52	7.69
III, postoperative	0.50	49.51	15.36	15.61

Tests of the exponents against their theoretical values are given in Table 2. The area exponent is compatible with the orifice value $\alpha = 1$ ($t = -1.23$, $p = 0.31$) but incompatible with the Poiseuille value $\alpha = 2$ ($t = -4.29$, $p = 0.023$). The pressure

exponent is compatible with both candidate values, so the data do not discriminate between them; its confidence interval spans −0.53 to 3.25.

Table 2. Estimated exponents and tests against the limiting hydrodynamic laws

Parameter	Estimate	SE	95 % CI	Null value	p
α	0.599	0.326	−0.439 to 1.638	1 (orifice)	0.307
α	0.599	0.326	−0.439 to 1.638	2 (Poiseuille)	**0.023**
β	1.360	0.593	−0.527 to 3.246	1/2 (orifice)	0.243
β	1.360	0.593	−0.527 to 3.246	1 (Poiseuille)	0.587

Discussion

The estimated area exponent excludes the quadratic dependence required by Poiseuille flow but is consistent with the linear dependence of an orifice discharge. Physically this indicates that flow is governed by a short constriction rather than by distributed viscous resistance along the whole urethral length, which is what would be expected if a valve remnant or the flow-controlling zone dominates the pressure drop. The pressure exponent is poorly determined because p_{det} varies over a narrow range in these data — from 34.9 to 49.5 cmH_2O, a factor of only 1.42 — so its logarithm carries little information. Widening that range, which would require including unoperated controls or patients with severe obstruction, is the direct way to resolve β.

The high coefficient of determination should not be over-interpreted. With six observations and three parameters only three residual degrees of freedom remain, and the confidence intervals for both exponents are correspondingly wide. The estimates are reported as a first empirical calibration of the functional form rather than as definitive values.

Conclusion

A two-exponent allometric law reproduces the observed pressure–flow states to within about 5 %. The fitted area exponent of 0.60 ± 0.33 is inconsistent with Hagen–Poiseuille scaling and consistent with orifice discharge, supporting the modelling of the obstructed paediatric urethra as a localised constriction. Estimation on individual rather than group-level data, over a wider pressure range, is required to determine the pressure exponent.

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