EDITORIAL COMMENT

UROLITHIASIS

What endourology can learn from urodynamics: towards safe and standardized intrarenal pressure monitoring and use of suction irrigation pressure auto-regulating systems (SIPS)

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Technological progress in upper urinary tract endoscopy is currently among the fastest evolving areas of urology. The widespread adoption of retrograde intrarenal surgery (RIRS), the introduction of high-power laser systems, flexible ureteral access sheaths, and suction-assisted technologies have all occurred within little more than a decade.

Among these innovations, suction has probably had the greatest impact on the management of urinary stones [1]. By enabling simultaneous fragmentation and evacuation of stone debris, it has shifted the paradigm of RIRS from simple lithotripsy aimed at producing fine dust to an active strategy of fragmentation and aspiration, with the goal of achieving a truly stone- and dust-free status [2].

However, the introduction of suction has also highlighted a fundamental challenge: the occurrence of rapid and sometimes substantial fluctuations in intrarenal pressure during endoscopic procedures. Maintaining a stable pressure environment soon became a priority. Technology responded quickly by introducing systems equipped with pressure sensors and automated algorithms capable of regulating irrigation inflow and suction outflow in real time [3].

At first glance, this appears to be the ideal solution. A closed-loop system maintains a stable operative environment, balancing inflow and outflow to provide optimal visibility, safe intrarenal pressures, and efficient evacuation of stone fragments. Such systems promise faster, safer, and more effective treatment of increasingly complex stone burdens through a purely retrograde approach.

Yet the emergence of these technologies raises several important questions:

- Do we have a consensus regarding what constitutes a safe intrarenal pressure?
- Do we even agree on the units that should be used when reporting pressure measurements (cmH_2O vs mmHg)?
- Is patient safety determined primarily by the peak pressure reached during the procedure,

or by the cumulative duration of exposure to elevated pressures – call it "pressure burden"?
- How certain are we that the values displayed by modern systems accurately reflect the true pressure within the collecting system?
- Who should be responsible for supervising pressure monitoring and recognising signs of measurement failure? Do we need an assistant for that?
- Do automated systems that regulate irrigation based on pressure readings contain sufficient safeguards against sensor malfunction or falsely low pressure values that could lead to excessive irrigation?
- How and when should pressure sensors be verified or calibrated?
- How should zero reference values be established?
- Do ureteroscopes equipped with pressure sensors provide measurements equivalent to those obtained from pressure-sensing access sheaths?
- Finally, which strategy is safest: fully automated regulation, fully manual control of irrigation and suction, automatic adjustment of suction to predefined irrigation settings, or automatic adjustment of irrigation according to suction performance?

Interestingly, some of these questions may be approached by looking beyond endourology and revisiting principles that have long been established in lower urinary tract urodynamics.

More than two decades ago, the International Continence Society (ICS) recognized the need for standardization of pressure measurements and interpretation. The objective was straightforward: to ensure reproducible and comparable results between centres while minimizing technical errors and misinterpretation.

In its landmark Good Urodynamic Practices document published in 2002 [4], the ICS emphasized several principles that remain remarkably relevant for endourology today:
- "There should be continuous and careful observation of the signals as they are collected, and the continuous assessment of the qualitative and quantitative plausibility of all signals."
- "Any artifacts that occur should be corrected immediately."
- "Quality control relies on pattern recognition and a knowledge of normal values."
- "Zero pressure is the surrounding atmospheric pressure."
- "Calibration of all measurements should be possible."

Furthermore, the ICS stated that pressure recordings should be continuously assessed to ensure physiological plausibility and signal integrity.

Although these recommendations were originally developed for lower urinary tract urodynamics, several of them appear directly applicable to contemporary intrarenal pressure monitoring systems employing microtip pressure transducers.

While disposable sensors are calibrated by the manufacturer, the user should still be able to verify whether the calibration remains accurate. In practical terms, a measured pressure of 1 cmH_2O should correspond to a true pressure of 1 cmH_2O.

Similarly, zeroing should be performed in air before the sensor enters the urinary tract. Subsequent immersion of the sensor to a known depth in water – for example 10 cm – should generate a reading corresponding to the expected hydrostatic pressure (approximately 10 cmH_2O). Such a simple verification step may provide valuable reassurance regarding sensor accuracy before clinical use.

The use of mmHg rather than cmH_2O as the primary reporting unit further complicates interpretation and may unnecessarily distance pressure monitoring in endourology from established physiological concepts familiar to urologists through urodynamics.

Not every challenge associated with modern suction-assisted RIRS can be resolved by referring to a document written for bladder pressure measurements. Nevertheless, the discussion must begin. As pressure-monitoring and pressure-regulating systems become increasingly integrated into routine endourological practice, their implementation should be accompanied by structured education in what might be termed "upper urinary tract urodynamics" – including an understanding of pressure measurement principles, signal quality assessment, recognition of artifacts, and appropriate responses to abnormal readings.

The future of intrarenal pressure monitoring will depend not only on technological innovation but also on the development of a common language, standardized methodology, and quality-control principles. Urodynamics has already travelled this path. Endourology may now be facing a similar journey.

CONFLICTS OF INTEREST
The authors declare no conflict of interest.

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