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Research Letter

A novel technique for measurement of fluid absorption during ureteroscopy

In recent years, there has been a renewed interest in studying post-ureteroscopy infection and sepsis. One of the hypotheses involves the relationship between renal pelvis pressure and pyelovenous backflow – that is, the retrograde flow of urine containing bacteria or endotoxin into the bloodstream during ureteroscopy results in a significant inflammatory response and infection/sepsis [1,2].

The technique of adding a known concentration of ethanol to irrigation solution and calculating the rate of fluid absorption during urological procedures has been used historically to measure fluid absorption in TURP [3]. However, the risks of fluid absorption during monopolar TURP differ from those during ureteroscopy. In TURP, there is a risk of dilutional hyponatraemia when using hypotonic irrigation solution (e.g., glycine) In TURP, there is a risk of dilutional hyponatremia due to the absorption of hyptonic irrigation fluid into the bloodstream through opened prostatic vessels. However, in ureteroscopy, the concern is the retrograde backflow and absorption of infected urine [1].

Prior studies have evaluated fluid absorption during TURP, but there is a paucity of research exploring methods to measure fluid absorption during ureteroscopy. Given the recent evidence demonstrating a continual rise in the incidence of kidney stone disease [4], along with the fact that ureteroscopy has overtaken shockwave lithotripsy as the most common intervention for stone disease [5], a method of studying fluid absorption during ureteroscopy may help optimise patient outcomes and surgical technique. The purpose of this study was to evaluate the accuracy of the use of a standard 'off-the-shelf' breathalyser to measure serum alcohol levels and calculate fluid absorption in a live swine model of a 1-h ureteroscopy during which a known quantity of ethanol was added to the irrigation solution. Breathalyser measurements were compared with 'gold standard' serum venous ethanol concentrations, from which fluid absorption is typically calculated.

The research study was performed at CBSET, Inc. (Lexington, MA, USA) according to the guidelines outlined in the Guide for the Care and Use of Laboratory Animals. The Institutional Animal Care and Use Committee approved the procedures and complied with the Animal Welfare Act and Food and Drug Administration Regulations, including their amendments. All pigs were operated on under general anaesthesia.

A rigid cystoscope was used to insert a super-stiff guidewire into the pig's kidney, and a dual-lumen catheter was employed to place a pressure-sensing guidewire (Comet™; Boston Scientific Corp., Marlborough, MA, USA) with a diameter of 0.3556 mm (0.014″) into the renal pelvis for real-time pressure measurements. A flexible ureteroscope (Lithovue™; Boston Scientific Corp.) was passed over the super-stiff wire and positioned in the renal pelvis. Endoscopic assessment confirmed the correct positioning of the pressure-sensing wire and the ureteroscope in the renal pelvis. The ureteroscope and pressure-sensing guidewire remained stationary in the renal pelvis for 1 h with no manipulation. Renal pelvis pressure was maintained at predetermined levels (37, 55, 75 or 150 mmHg) across different animals, adjusted using real-time feedback from the pressure-sensing guidewire.

The irrigation solution was normal saline with 5% ethanol as a measurable analyte. The pig's blood alcohol level was verified to be 0 mg/dL at the onset of each procedure using a portable breathalyser (FC10™ Breathalyser; Lifeloc Technologies Inc., Wheat Ridge, CO, USA). To monitor the absorption rate, venous blood samples were collected through a jugular vein catheter every 10 min throughout the 1-h ureteroscopy procedure, continuing until the breathalyser detected and recorded the peak blood alcohol level.

Quantitative variables were summarised through measures of central tendency (mean and median) and dispersion (SD and interquartile range [IQR]). A correlation analysis was used to report the relationship of relevant variables. A *t* test was used for comparative statistics with P values < 0.05 taken to indicate statistical significance. The collected data were analysed using R software.

Flexible ureteroscopy was performed on 18 kidneys of anaesthetised female Yorkshire pigs, weighing approximately 60 kg each, at renal pelvis pressures of 37, 55, 75 and 150 mmHg cmH_2O. Intrarenal pressure was maintained with a pressure bag and real-time pressure monitoring using a pressure sensing guidewire. At the end of each procedure, a retrograde pyelogram was performed to evaluate for renal collecting system injury.

The median (IQR) ethanol absorption during irrigation was 0 (8.5) mL/dL, 11.7 (13.9) mL/dL, 20.7 (22.9) mL/dL, and 56.8 (15.8) mL/dL, respectively. Concurrently, assessing breathalyser ethanol levels at the same renal pressures showed median (IQR) ethanol concentrations of 0 (7) mL/dL, 13 (13) mL/dL, 20 (30.5) mL/dL and 70 (21) mL/dL. At a target renal pressure of 37 mmHg, ethanol

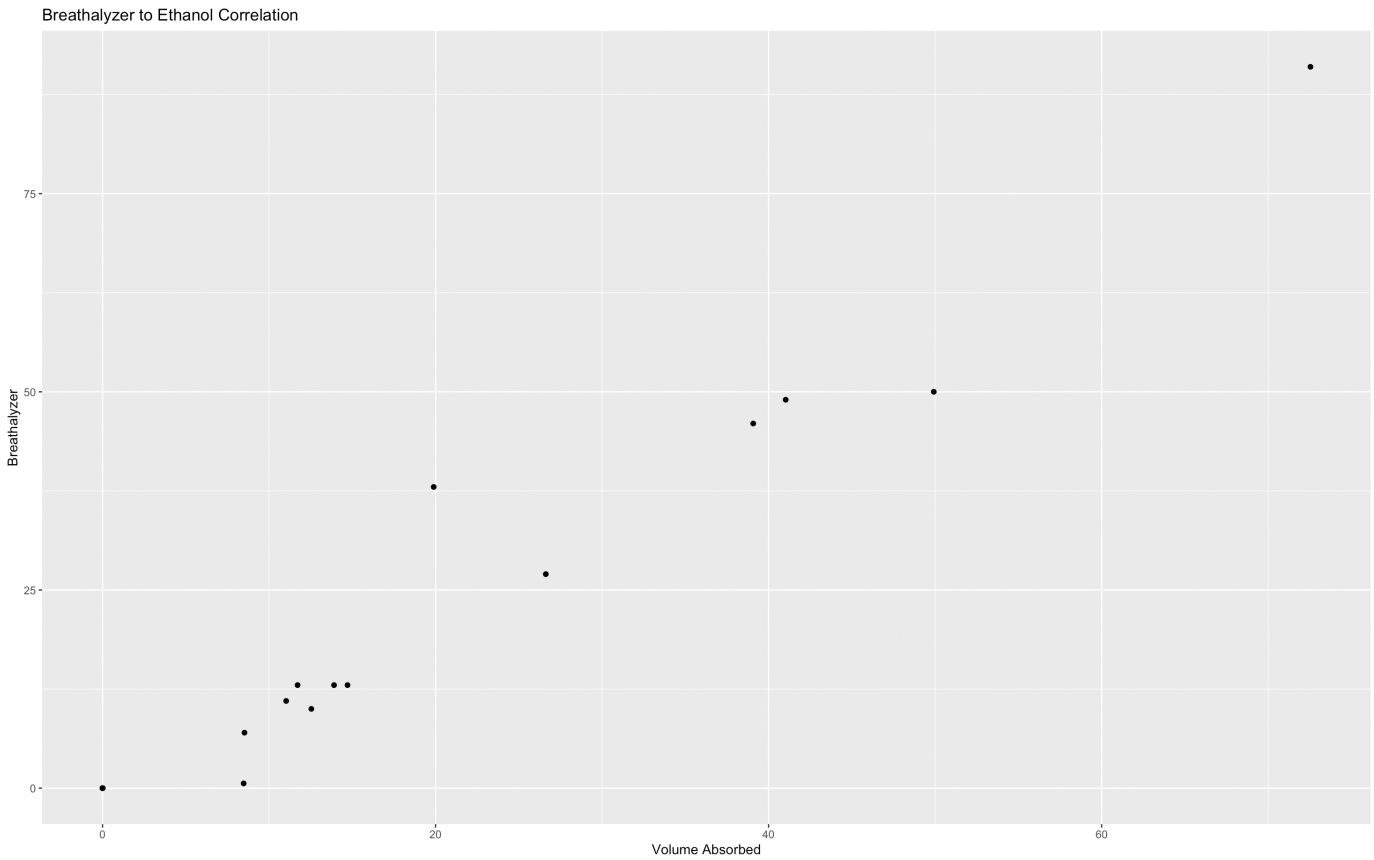
absorption volume and breathalyser ethanol levels were undetectable in three of five procedures. Similarly, at a target renal pressure of 55 mmHg, two out of five procedures yielded undetectable levels. Ethanol levels exhibited consistent detection in pigs' breath and blood at 75 mmHg or higher pressures. Fluid absorption was significantly higher at 75 mmHg compared to 37 mmHg ($P < 0.05$). The Pearson correlation coefficient between breathalyser ethanol levels and ethanol absorption was 0.978 ($P < 0.01$; Fig. 1). Following the procedure, retrograde pyelogram assessments revealed no signs of extravasation or injury in any of the experimental animals.

In a previous study from our group, we described the use of ethanol in irrigation solution during ureteroscopy to evaluate fluid absorption. In that study, we utilised serum venous sampling to evaluate blood ethanol levels [6]. In the current study, we evaluated the correlation between the serum venous ethanol concentrations and breathalysed samples using an off-the-shelf breathalyser. The advantages of using an expired breathalysed sample include lower costs, reduced invasiveness, and decreased risk/morbidity versus phlebotomy. Our study demonstrated a Pearson correlation coefficient of 0.987 ($P < 0.01$), a highly positive correlation, suggesting that it would be appropriate and reasonable to use breathalysed samples to study serum ethanol concentrations in the ureteroscopy model described above.

Our results are consistent with findings in previous TURP studies that used expired breath ethanol. Hjertberg et al. [7] showed that the ethanol concentration in the breathalyser correlated strongly with the degree of absorption of intravascular irrigation fluid during TURP. The authors also demonstrated that elevated bladder and prostatic fossa pressure was a prerequisite for absorbing irrigation fluid. Studies from that group showed that pressure warning devices could reduce the volume of irrigation absorbed, thus decreasing adverse effects [8]. In our porcine study we observed a strong correlation ($r = 0.98$) between the absorbed volume and breath ethanol levels. Additionally, we found a significantly greater volume of fluid absorption at 75 and 150 mmHg compared with 37 mmHg ($P < 0.05$). Notably, at a blood ethanol level of less than 50 mg/dL, a human is not considered to be intoxicated.

It is important to consider variables that may potentially influence the outcomes of this study. One such factor is using an animal rather than a live human model. We hope that our

Fig. 1 Pearson correlation between serum ethanol levels and ethanol levels measured by breathalyser test. Correlation coefficient was 0.978 ($P < 0.01$).



group and other investigators in the future may have the opportunity to study this phenomenon in humans to truly understand the utility of measuring fluid absorption during ureteroscopy.

Re-evaluating ethanol's role in enhancing safety and optimising patient outcomes could enhance the urological community's understanding of ureteroscopy and how to reduce the risk of post-ureteroscopy infection. The breathalyser technique could represent a non-invasive, cost-effective method of measuring fluid absorption during ureteroscopy. Moreover, if integrated into a meticulous study, it holds promise for correlating with infectious outcomes post-ureteroscopy.

Disclosure of Interests

Brian Eisner – Consultant for Boston Scientific. Jennifer Saunders – Employee of Boston Scientific. All other authors: no conflict of interest.

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Abbreviation: IQR, interquartile range.

Preliminary findings on vitamin D 25-OH levels in urine analysis: implications for clinical practice

The high frequency and recurrence of UTIs contribute to diminished quality of life, increased healthcare expenditure and extensive use of antimicrobial agents [1,2]. Various diagnostic biomarkers are available to support clinical decision-making, aiding early detection and prognosis of UTIs and associated urosepsis. Blood test analysis, encompassing white blood cell count, neutrophil to lymphocyte ratio, procalcitonin, interleukin-6, C-reactive protein, lactate and long noncoding RNA, plays a crucial role [3]. Ongoing UTI research predominantly concentrates on enhancing diagnostics and innovating therapeutic and preventive approaches, such as novel antimicrobials and vaccines.

Urine analysis remains a valuable diagnostic tool that helps clinicians when faced with UTIs and during the preoperative phase in patients with kidney stones. Many uncomplicated UTIs will resolve without any treatment, with only symptomatic therapy, resulting in favourable outcomes; others may pose severe complications. Risk factors can contribute to a more complex scenario, leading to a less optimistic prognosis and potential treatment failure [4]. In the clinical setting, it is important to recognize the appropriate timing for proposing more aggressive therapy to prevent the infection from speading to the upper urinary tract and developing intopyelonephritis. Furthermore, recurrent UTIs present a notable clinical challenge and impact a considerable portion of the population, especially women. Antibiotic therapy remains the cornerstone of treatment, but the increasing prevalence of antimicrobial resistance necessitates a thoughtful and evidence-based approach.