Intermittent Catheter Coating Residues Compromising Spermatozoa Motility: A Novel Fertility Consideration for Spinal Cord Injury Patients

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Background

Intermittent catheters (ICs) are commonly used to alleviate chronic urinary retention in individuals suffering from neurogenic bladder dysfunction, most notably patients with spinal cord injury (SCI) (1). The majority of ICs are coated with hydrophilic polymers, such as **polyvinylpyrrolidone** (PVP), to reduce friction and discomfort during catheterisation. However, these coatings can delaminate during use, resulting in coating residue remaining within the urethra. Repeated catheterisation coupled with a lack of a natural urethral flushing mechanism in SCI patients may encourage a build-up of PVP within the urinary tract.

Interestingly, PVP is exploited clinically for intracytoplasmic sperm injection (ICSI) to reduce **spermatozoa motility** and under long-term exposure can alter **spermatozoa morphology** (2). Patients with SCI are predisposed to infertility (3). It is hypothesised that repeated exposure to PVP from hydrophilic-coated ICs may impair spermatozoa function, potentially contributing to a further risk factor for **infertility** in patients with SCI.

Methods

Porcine semen (Deer Park, Gloucester Old Spot, Reg No.R012707GS UKPO5) diluted 1:4 with an antimicrobial extender (53.3 % penicillin, 26.7 % polymyxin E, 13.3 % kanamycin and 20 % neomycin) was enumerated using a haemocytometer and diluted in phosphate-buffered saline to an average human sperm count of 23.5 million/mL.

Methods Cont'd

1.5 mL of diluted sperm (a volume representative of average human ejaculate) was heated to 34°C and artificially ejaculated (1000 mm min^{-1}) through a previously catheterised *ex vivo* porcine urethral model, using a texture analyser.

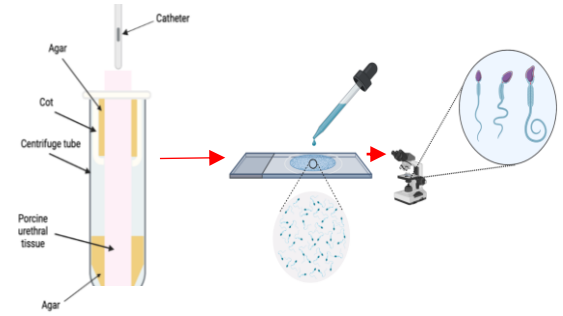

Figure 1. Catheterisation of a 360° *ex vivo* porcine urethral model, followed by artificial ejaculation of semen and microscopic assessment of spermatozoa morphology.

The urethral model underwent a single catheterisation or five repeated catheterisations (representative of daily use) with three commercially available intermittent catheters (CH 10): two hydrophilic PVP-coated catheters and one incorporating an amphiphilic surfactant (IAS). Immediately following ejaculation, the percentage of abnormal sperm morphology was evaluated microscopically (**Figure 1**). Random fields of view were captured and defects in the spermatozoa head, midpiece, and tail identified. Videos of spermatozoa were captured, and spermatozoa motility (µm/sec) was analysed using ImageJ, measuring the distance travelled per second.

Results

Spermatozoa Morphology

No significant changes in spermatozoa morphology were observed for any catheter brand after artificial ejaculation through the *ex vivo* model following 1 or 5 insertions. Structural integrity was therefore maintained.

Spermatozoa Motility

A significant reduction in progressive spermatozoa motility ($p<0.001$) was observed, with velocities falling below the critical threshold of 25 µm/s required for successful human fertilisation. Following a single catheterisation of the model, spermatozoa motility was reduced by 56.85% ± 13.30% and 62.33% ± 8.71% with PVP-coated catheters Brand 1 and Brand 2, respectively, relative to the uncatheterised control (**Figure 2**). No significant differences in spermatozoa motility were observed between 1 and 5 insertions for any catheter type.

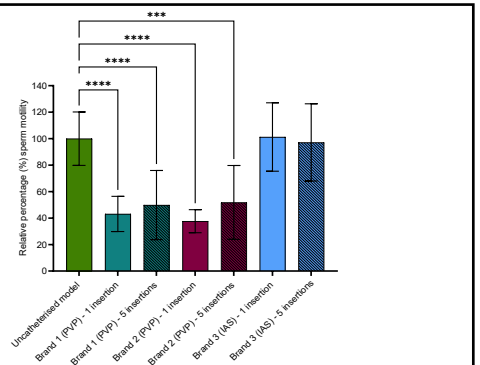

Figure 2. Percentage spermatozoa motility relative to uncatheterised control upon artificial ejaculation through an *ex vivo* model following 1 catheter and 5 catheter insertions. Error bars represent S.D.s of the mean values (n=5)

A two--way ANOVA with Tukey's multiple comparisons test was performed (n=5). Asterisks represents a significance of *** $P \leq 0.001$ and **** $P \leq 0.0001$.

Results Cont'd

Microscopic analysis revealed expelled catheter coating debris alongside the spermatozoa, with those trapped within the residual material exhibiting immobilisation. Decapitated spermatozoa were also observed within the coating debris (**Figure 3**).

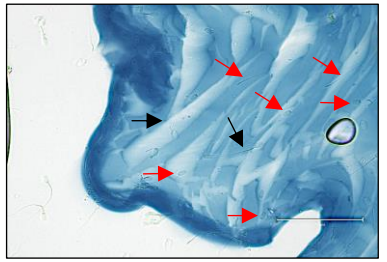

Figure 3. Spermatozoa immobilized within residual catheter coating debris. Black arrows = intact cell, red arrows = decapitated fragments (heads/tails). Catheters were pre-stained with trypan blue before insertion to aid visualisation. Images acquired with light microscopy at x100 magnification. Scale bar 75 µm.

Implications

Exposure to residual PVP within the urethra was found to negatively affect spermatozoa motility. In individuals with SCI, PVP accumulation may represent an unrecognised contributor to reduced fertility by directly entrapping sperm or restricting flagellar movement, further hindering sperm transport and compounding existing reproductive challenges in this population.

References & Acknowledgements

1. Pollard (et al.), Biotribology 2022; 32:100223.
2. Sabour (et al.), Andrologia 2022; 54: e14402.
3. Sinha (et al)., Topics in Spinal Cord Injury Rehabilitation 2017; 23 (1), 31- 41.