

Genitourinary infection and barotrauma as complications of 'P-valve' use in drysuit divers

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Key words

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Abstract

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Drysuits are commonly worn by divers undertaking long exposures in cold water. The need to urinate during such dives leads to the use of a variety of devices to conduct urine from the diver to the ambient water. The final common pathway to the water is via a suit bulkhead known as a 'P-valve'. Use of the various urinary devices and P-valve can lead to a number of complications including urogenital sepsis, pneumaturia and genital squeeze. The urinary devices in current use are described, then four clinical cases that illustrate the complications are presented. Recommendations for prevention of these complications are made.

Introduction

Drysuits are worn as thermal protection when diving in cold water, when exposures are prolonged or as physical protection when the water is contaminated. The need to urinate while wearing a drysuit during lengthy dives has led to the development of techniques and devices that allow this. The increasing popularity of technical diving has seen more divers with this need.

Male divers use either nappies or a condom catheter system. In the latter case, an adhesive urinary condom catheter is attached to the penis before the drysuit is donned. The condom is then connected to a plastic or rubber tube that exits the drysuit via a special bulkhead valve known as a 'P-valve'. Female divers have been limited in their choice of technique. Absorbent nappies have been the mainstay for women in drysuit diving but more recently devices like the Shewee Go® or She-P® (Figure 1) have offered an alternative. In female divers, a latex or silicone cup is either held against or adhered to the external genitalia collects then drains urine via an identical tubing system to that utilised by male divers. These systems may effect an airtight seal as with the male condoms.

P-valve systems come in two basic varieties: unbalanced

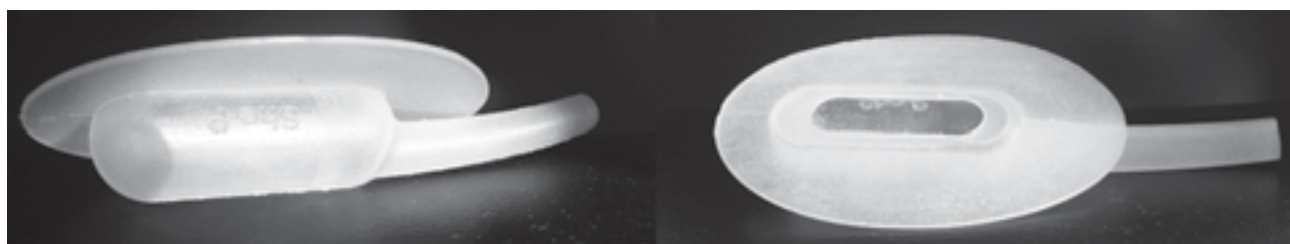
or balanced. In the unbalanced version, a screw valve on the outside of the suit is opened when the diver wishes to urinate. This is usually closed after urinating to prevent drysuit flooding in the event the condom falls off or becomes disconnected. The balanced P-valve utilises an additional chamber (inside the suit) to equalise the pressure within the tubing with the ambient pressure (Figure 2). One-way check valves may also prevent suit flooding in the event of accidental disconnection.

The use of P-valves and their accessories is not free of complications, and five complications in three divers relating to their use are reported here. These include catheter squeeze, urogenital infections and pneumaturia.

Case one

A technical diver approximately 40 years of age was involved in a two-week diving project on a shipwreck in the Sea of Marmara, Turkey. The diver was performing one decompression dive per day to a maximum of 70 metres' sea water (msw) using a closed-circuit rebreather. Thermal protection was drysuit based. During the dives urination was facilitated via an unbalanced P-valve. After approximately five days of diving, the subject developed symptoms and signs consistent with urinary sepsis: initially malaise,

Figure 1
A commercially available female urine collecting system, the 'She P'®



vomiting and dysuria, which progressed to loin pain, fever and rigors. Due to the remoteness of the location, empirical treatment was commenced with intravenous gentamicin and ciprofloxacin, and rehydration. The diver's condition gradually improved over the next 24 hours. Follow-up testing could demonstrate no abnormality on urine microbiology, plain abdominal X-ray looking for calculi, or ultrasound scan of the urogenital tract.

Case two

The author, a 44-year-old cave diver, was about to submerge in the cold (6.5°C) waters of an Australian cave. He was standing in chest-deep water and opened his unbalanced P-valve in order to urinate before commencing the dive. At that moment, he distinctly felt some cold water flow in a retrograde fashion through the condom catheter into his bladder. Approximately 48 hours later he began to feel systemically unwell: initially malaise and anorexia, then diarrhoea and night sweats. The following day he developed dysuria, frequency and urgency. Loin pain and rigors followed, suggesting urinary tract infection. Moderate discomfort in the perineal region also raised the possibility of acute prostatitis. The author attended a hospital emergency department and was treated with intravenous gentamicin and cephalothin, and discharged with oral cephalixin. Symptoms were very slow to settle over the next seven days and so the antibiotic was changed to oral norfloxacin with good effect. Initial urine microbiology was negative but microscopy showed large numbers of white and red blood cells.

Six weeks later, the symptoms suddenly recurred in the absence of diving. On this occasion, urine culture grew *Pseudomonas aeruginosa*, sensitive to norfloxacin. Prostate-specific antigen was high at 11 ug.L⁻¹ (normal range 0–4). Plain abdominal X-ray, and renal and prostatic ultrasound were normal. A diagnosis of relapsing acute prostatitis was made and was successfully treated with a two-month course of oral norfloxacin.

Case three

A 49-year-old drysuit diver performed a 60-minute, 7-msw dive in the ocean. He was using a condom catheter connected to a balanced P-valve. Twenty-five minutes into the dive he attempted to urinate. He immediately felt a sharp pain in the penis, forcing him to abort the dive and ascend. Assuming the tubing to the P-valve was obstructed, he inflated his drysuit fully and managed to ease his discomfort somewhat. He finished the dive and, after exiting the water, opened his drysuit to find the condom "ballooned" with urine secondary to a kinked tube distally.

That night he developed dysuria, constipation, generalised aching and 'flu-like' symptoms. He then developed urinary frequency, fever and rigors. The next day he was admitted to hospital with a urinary tract infection, where he remained for six days on intravenous antibiotics (drug unknown). Urine and blood cultured *Pseudomonas aeruginosa*.

Case four

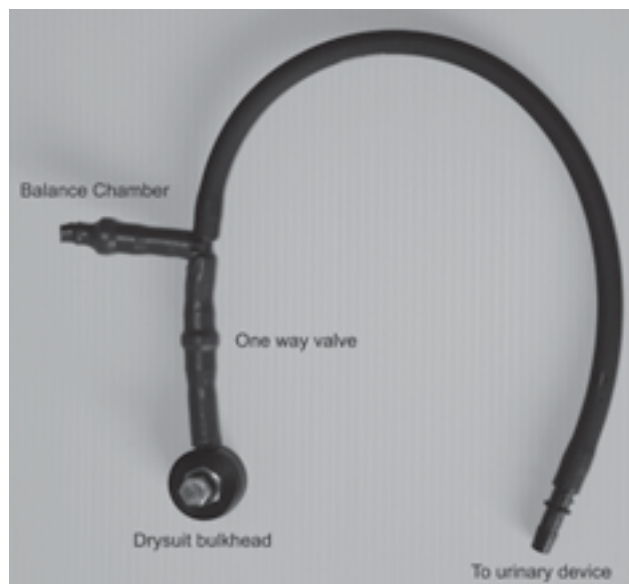
The author can also report on a dual complication relating to an unbalanced P-valve. On a drysuit dive to 60 metres' fresh water in a sinkhole, inadequate drysuit inflation led to a sudden and distressing sensation of a "squeeze" on the condom catheter and penis. This required immediate action on the part of the author with a two-part remedy. Firstly the suit was inflated with compressed air to decrease the overall drysuit squeeze. Secondly, the screw valve on the bulkhead was opened to decompress the offending tubing. The author experienced dramatic relief, but also noted a disturbing retrograde flow of what felt like air into his bladder as the valve was opened. On surfacing after the dive, these events were confirmed by the presence of bruising on the distal portion of the penis, and pneumaturia that persisted for the next 12 hours.

Discussion

The use of P-valves and urinary condom catheters is commonplace in male drysuit divers. The new devices now available for women may form an airtight seal and so in theory may generate a similar set of complications. In males between the ages of three months and 50 years, acute bacterial urogenital tract infection is a rare event in the absence of an anatomical abnormality, a disorder of bladder emptying or a mechanical 'breach' of the body's normal defences (such as catheterisation).¹ Hence, it is likely that

Figure 2

A 'balanced' (left/right) P-valve system, showing the balance chamber and one-way valve. The drysuit bulkhead can also be seen; this tube can be connected to either a male (condom catheter) or female (e.g., the 'She P'®) urine-collecting system



the use of P-valves in the divers described was causative in the urogenital infections the divers experienced.

The origin of the *Pseudomonas sp.* in two of the divers is likely to be the drysuit tubing. After diving, the drysuit is stored and residual urine or water will dwell in the P-valve tubing. This is a perfect culture medium for *Pseudomonas*. In the author's view, the bacteria are far less likely to be introduced from the cave or ocean environment in these cases. The proposed mechanism for these infections is by retrograde inoculation with bacteria into the urogenital tract, or from bacteria in the tubing being held in close proximity to the urethral meatus. The fact that retrograde flow can occur in this setting was clearly demonstrated by the presence of pneumaturia in case four.

Pseudomonas sp. are tolerant to a wide variety of physical conditions including high salt concentrations, low nutrient concentrations and weak antiseptics. The organism is flagellated and motile, aiding movement through aqueous media.² Urinary tract infections caused by *Pseudomonas aeruginosa* are usually hospital-acquired and related to urinary tract catheterisation. Community-acquired pseudomonas urosepsis is far less common.³ Because of its frequent resistance to antibiotics and its production of potent endotoxins, Gram-negative pseudomonas sepsis carries significant morbidity and mortality. In these cases, routine follow-up investigations looking for calculi or anatomical anomalies were non-contributory. This further suggests that a mechanical breach of normal defences, or direct inoculation into the urethral meatus was the cause.

Two divers were using unbalanced P-valves. The use of balanced systems with their one-way valves should in theory prevent any retrograde flow of air or water into the diver, and hence reduce such complications. However, an obstruction to flow in case four still may have generated some retrograde movement of urine into the urethra despite the use of a balanced P-valve. One strategy for users of unbalanced valves is to 'prime' the tubes with incompressible urine before entering the water. More care with equalising the drysuit to ambient pressure during descent may also prevent retrograde flow through the drainage system, as well as avoiding squeeze of the external genitalia. Commencing the dive with the P-valve in the open position should also prevent squeeze, but increases the risk of a suit flood in the event of accidental disconnection of the tubing.

Perhaps the most important strategy in the prevention of urinary sepsis is adequate cleaning of the P-valve tubing after use and before storage. Syringing an antiseptic such as chlorhexidine through the tubing could accomplish this. Alternatively a solution of methylated spirits and acetic acid (3:1) might be used, as it appears to be effective in preventing pseudomonas infections (e.g., in the external ear canal).

A final complication of the drysuit P-valve is catastrophic suit flooding. Any breach in the system e.g., accidental

disconnection of the tubing from the condom catheter in conjunction with a failure to close the external bulkhead, will allow the drysuit to fill with water. Water in the drysuit will not only increase the risk of hypothermia but may adversely affect the diver's buoyancy, and prevent them surfacing. A major drysuit flood in very cold water, in a diver with a decompression obligation of several hours, may well have a fatal outcome.

An informal survey by the author of drysuit divers via an internet forum and an email list, also revealed numerous episodes of urinary tract infections, genital squeeze, positive pressure incidents and pneumaturia associated with the use of newer urine-collecting devices in women, and condom catheters in men. Therefore, this is a potentially serious problem that could lead to long-term health problems in divers undertaking prolonged dives in drysuits. Education in cleaning and care of these devices should become part of technical diving training.

Conclusions

To the author's knowledge these are the first documented cases of complications arising from the use of P-valves in drysuit divers. Complications like urogenital sepsis in males and females, pneumaturia and external genital squeeze may be significantly under-reported. The use of balanced (c.f. unbalanced) P-valves may decrease the likelihood of all these complications arising. Greater awareness of these problems may lead to earlier recognition, diagnosis and treatment of urogenital sepsis; whilst better technique and improved post-dive hygiene may decrease the incidence of the complications described.

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