Leakage Associated with Urinary Catheter Usage: A Design Challenge

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Roe and Brocklehurst (1987) identified indwelling bladder catheter-associated leakage, or catheter bypassing, as one adverse effect of these devices, resulting in distress and embarrassment for the patient. There is a paucity of research literature related to bladder catheter leakage, resulting in the lack of identifiable or standard interventions. Thus, prevention of bladder catheter leakage remains a challenging clinical scenario, with clinicians relying on anecdotally known remedies. Based on clinical expertise, the authors propose that an alteration in the current indwelling bladder catheter design may be an appropriate intervention toward decreasing the incidence of catheter leakage. This is based on the premise that leakage is the result of the catheter tip becoming kinked when bladder spasms occur. This kink occludes the two openings, or eyes, located on the catheter tip. Thus, urine bypasses the catheter, or leaks. Modification of the bladder catheter, along with formal research, should be performed to determine the effect of this hypothesis.

Catheter bypassing, or indwelling bladder catheter-associated leakage, is a frequently experienced problem, necessitating a carefully planned intervention. Once a bladder catheter is in place, urine may flow intermittently between the catheter shaft and the urethra mucosa, or from around the catheter when inserted suprapubically. A review of the literature identified several reasons for this leakage, including catheter size and anatomical abnormalities. Based on clinical experience, the authors posit that indwelling catheter leakage may also occur as a result of a catheter design flaw. This article provides the theoretical rationale for this hypothesis and a potential solution; formal, rigorous, and appropriate research should be performed to test the hypothesis.

Key Words: Bladder catheter bypass, bladder catheter-associated leakage, indwelling bladder catheter.

Literature Review

A literature review was undertaken without limit of time using the BNI, OVID, CINAHL, and MEDLINE search engines and the keywords catheter, bypassing, leak, urinary, suprapubic, and indwelling. A result of this search
identified three research articles related to indwelling bladder catheter leakage. The first of these articles describes a successful use of an injection of *Botulinum-A* toxin into the bladder wall of three patients during a cystoscopy procedure performed to reduce catheter leakage (Lekka & Lee, 2006). The second article uses a case study to discuss the success related to altering the catheter by placing extra holes below the catheter balloon, which successfully eliminated catheter leakage (Mohapatra, 2010). The last article, also a case study, describes the positive results, defined as leakage stoppage, when an additional hole was placed at the very end of the catheter above the two current holes. This intervention successfully stopped the leakage of a suprapubic catheter (Vaidyanathan, Soni, Hughes, & Singh, 2009). None of these articles identified a cause or causes for the catheter leakage; thus, recommended interventions cannot be generalized.

While a myriad of articles were identified using the key words *catheter, bypassing, leak, urinary, suprapubic, and indwelling*, these articles focus on catheter care in general. Catheter leakage is frequently mentioned as a problem along with other catheter problems, such as catheter-associated urinary tract infection (CAUTI), catheter blockage, difficult catheter insertion, and catheter expulsion. These articles provide anecdotal evidence with respect to the possible cause of catheter leakage and suggest techniques aimed at managing this problem. These interventions are based on professional opinions rather than clinical research, with the rare reference indicative of other health care professionals’ opinions. Tables 1 and 2 present a list of authors and their opinions of the cause(s) of catheter leakage and its management.

### Table 1.

**Catheter Leakage Accompanied by Bladder Spasms**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Cause(s) for Catheter Leakage</th>
<th>Interventions Suggested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cruickshank &amp; Woodward, 2001</td>
<td>Bladder overactivity, large catheter diameter that irritates the bladder trigone, large catheter balloon that irritates the bladder trigone, an under-inflated catheter balloon that causes the catheter tip to touch the bladder wall causing irritation.</td>
<td>A smaller size catheter, anticholinergic medication, smaller catheter balloon, inflation of the balloon at manufacturers’ recommendations.</td>
</tr>
<tr>
<td>Daughty, 2000</td>
<td>Concentrated urine that irritates the bladder wall.</td>
<td>Increase fluid intake.</td>
</tr>
<tr>
<td>Getliffe &amp; Dolman, 2003</td>
<td>An under-inflated catheter balloon that causes the catheter tip to touch the bladder wall causing irritation. Catheter-associated urinary tract infection (CAUTI), kinked tubing, constipation.</td>
<td>Inflate balloon at manufacturers’ recommendations.</td>
</tr>
<tr>
<td>Wilde, 1997</td>
<td>Large catheter and balloon that irritates the bladder trigone.</td>
<td>None</td>
</tr>
</tbody>
</table>

### Table 2.

**Catheter Leakage Associated with Luminal Occlusion**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Cause(s) for Catheter Leakage</th>
<th>Interventions Suggested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getliffe, 2003</td>
<td>Encrustation of the catheter lumen or eyes.</td>
<td>Catheter change, bladder washouts with Suby G (3.23% citric acid solution) solution to prevent occlusion by encrustation</td>
</tr>
<tr>
<td>Getliffe &amp; Dolman, 2003</td>
<td>Kinked drainage tubing.</td>
<td>“Check for kinked tubing” (p. 290).</td>
</tr>
<tr>
<td>Pomflet, 2000</td>
<td>Blockage of the catheter eyes by the bladder mucosa due to hydrostatical suction.</td>
<td>Instill 20 to 30 ml of sterile water or saline into the catheter, raise the urine drainage bag above the level of the bladder for a short period of time, drainage bag positioned at less than 30 cm below the bladder.</td>
</tr>
<tr>
<td>Rigby, 1998</td>
<td>Constipation, which can cause pressure on the drainage lumen, preventing the catheter from draining.</td>
<td>Treat constipation.</td>
</tr>
</tbody>
</table>
Using a retrospective research design, Roe and Brocklehurst (1987) explored the experience of having an indwelling urinary catheter from the patient’s perspective. Data were obtained from 36 community-dwelling patients who had an indwelling urinary catheter. Demographically, 20 (56%) were male, with a mean age of 68.9 years (range 50 to 93); 28 (78%) were living in their own home. The most reported (46%) reason for catheter placement was as treatment of urinary retention. Forty-four percent of these patients reported using a catheter for five years or more, with 33% reporting a diagnosis of multiple sclerosis. Results of this study revealed that these individuals had both understanding and knowledge of their catheter’s location and function, its acceptance, problems associated with its use, social implications, and subsequent management. Analysis of the interviews determined that the majority of these participants (89%) experienced leakage of urine around the catheter, resulting in wet clothing and bedding. The median occurrence of this leakage was reported as once a week. Four participants (11%) stated they had had no incidences of catheter-associated leakage or bypassing. Of the 89% that reported incidences of catheter leakage, 22 (61%) were able to identify factors that precipitated this leakage: five (14%) stated this occurred while having a bowel movement; 6 (17%) stated leakage occurred when they were constipated; the remaining 11 (31%) associated catheter leakage during a combination of activities. These include position changes, coughing, movement of any kind, and during a bowel movement in any combination. Twenty-six (72%) of these participants stated they could do nothing to prevent leakage of urine, although 6 (17%) would change their position or their catheter to prevent leakage. Twenty-three (64%) participants reported catheter blockages, which resulted in impaired flow of urine with a median occurrence between 1 and 3 months.

Research by Getliffe (1994) determined that 47% of the study population experienced catheter leakage. The purpose of this study was to determine if patients with indwelling catheters can be identified as “blockers” or “non-blockers” and to identify factors that contribute to recurrent catheter encrustation and blockage. A secondary finding was the incidence of catheter leakage, or bypassing. Interview data were obtained from 42 patients who resided either in their own homes or in warden-controlled housing. Female participants (77.8%) had a median age of 70 years, while male participants (22.2%) reported a median age of 77.5 years. Reasons for catheterization included incontinence (73.8%) and urinary retention (23.8%). One patient used a urinary catheter to provide relief from diurnal and nocturnal urinary frequency. The study failed to denote how long these patients had been using catheters and how often leakage occurred.

In a study by Kennedy and Brocklehurst (1982), 40% of the study population experienced catheter bypassing, a result that was not dependent upon the catheter placement site. Twenty-eight (32%) of these individuals in hospitals and community settings underwent a catheter change because of leakage. The aim of this study was to investigate the nursing management of patients with long-term indwelling catheters and to describe methods used to manage catheter problems. Of the 107 participants, 39 (37%) resided in the community and 68 (63%) were hospitalized. The hospitalized participants had a hospital stay between 1 to 416 weeks (median 20 weeks). The gender and age of these participants were not reported, but catheter placement was stated to have occurred after 2 weeks and lasted greater than 104 weeks.

In a review article, Wilde (1997) provides a summary of the literature focused on urinary catheter care, and identified major areas of research and gaps in knowledge. Catheter leakage, according to this summary, appears to be very common and occurred between 40% and 87% of the time. This review concludes that most research in the previous decade has focused on understanding how catheter encrustations develop and how such encrustations may contribute to leaking/blockage of the catheter and urinary tract infection. Despite the large percentages of catheter leakage reported, Wilde (1997) fails to recommend further research for catheter leakage.

Health literature provides several hypotheses for indwelling bladder catheter-associated leakage. These hypotheses can be divided into two main categories – 1) leakage accompanied with bladder spasms where occlusion of the catheter lumen or the drainage tubing has not been identified, and 2) leakage associated with occlusion of the catheter lumen or the drainage tubing. Definitive research correlating bladder catheter-associated leakage to bladder spasms was not found in the literature. Since 1987, when Roe and Brocklehurst reported that 72% of their study population stated that in their perspective, nothing could be done to prevent bypassing, little research attention has focused on this devastating consequence associated with the necessity of placing an indwelling bladder catheter.

A Conceptual Approach to the Cause and the Management Of Catheter Leakage

Catheter leakage associated with occlusion of the catheter lumen due to encrustation, debris, blood clots, or kinked drainage tube has been identified in the literature. It has not yet been possible to correlate indwelling bladder catheter leakage with bladder spasms. One aim of this article is to begin to bridge this knowledge gap. The
result of the literature review provides hypotheses related to indwelling bladder catheter leakage and bladder spasms, but the suggested methods of managing this problem have not undergone rigorous testing. These data are needed to provide evidence-based care, rather than treatment that is based on trial and error.

The authors hypothesize that one cause of indwelling urinary catheter leakage when associated with bladder spasms has yet to be identified. Thus, the authors hypothesize that a modification in bladder catheter design will alleviate this adverse effect. It is hoped that health professionals involved in research and medical device companies will consider this new concept in their research.

Normal Bladder Physiology

It is important to acknowledge that air is never normally present inside the bladder. Diagrams within health literature generally provide images of a catheterized bladder showing urine in the lower half and air in the upper half (Cruickshank & Woodward, 2001; Getliffe & Dolman, 2003; Nazarko, 2010). These diagrams suggest that urine drains through the catheter lumen and is replaced by air. This is not accurate; anatomy documents by Tortora and Grabowski (2008) demonstrate that an empty bladder is collapsed on itself. When empty, the bladder is then not hollow, and thus, cannot contain air.

Physiology of a Catheterized Bladder

When an indwelling bladder catheter is present, the bladder is unable to collapse entirely, prevented by the presence of the catheter tip and balloon. A pool of urine remains around a catheter within a free drainage system. Because an emptying bladder collapses on itself, the catheter tip, within a free drainage catheter system, does not remain straight. When the bladder deflates, its volume shrinks until it touches the catheter tip, resulting in a kink. The two catheter eyes are then occluded (see Figure 1). It is suggested that this enforced kinking of the catheter tip is the fundamental cause of leakage associated with bladder spasms. It is also suggested that when a urethral catheter is used, the pressure of organs above the bladder, called abdominal pressure in urodynamics, keeps the catheter tip kinked even as the bladder fills. In this case, the bladder volume increases horizontally but not vertically because the abdominal pressure prevents the bladder from lifting during the filling phase. When a detrusor contraction occurs, the only way for urine to be excreted is between the catheter shaft and the urethra mucosa because the catheter tip is kinked, blocking the eyes. This is usually accompanied by painful bladder contractions due to extra effort from the bladder to evacuate the urine. When the urethra is very tight around the catheter, contractions of the bladder can be ineffective in expulsing the urine. This results in an acute retention, which requires urgent intervention(s).

The authors have clinically determined that changing the catheter site from urethral to suprapubic usually diminishes or prevents leakage. In a suprapubic placement, the catheter tip is positioned horizontally, which is then not affected by the abdominal pressure. However, even in the presence of a suprapublically placed catheter, leakage can occur when the bladder becomes small and atrophic, and in the opinion of these authors, does not provide enough space for the catheter tip to remain straight.

The Clinical Scenario

The clinical experience of the first author includes four years as a community-based catheter care nurse. This required the coordination and provision of care to approximately 800 cases of complex catheter situations. These include difficult
catheter insertions, trials without catheter, catheter blockages, catheter bypassing, CAUTIs, and patients who are non-compliant. Based on the lead author's clinical experience and expertise, the following hypotheses support the notion that the catheter tip is kinked during episodes of leakage or bypassing.

- Changing an indwelling bladder catheter that is believed to be occluded does not prevent leakage. The catheter occlusion is usually not debris because urinary patency is re-established after an episode of leakage. If the leakage occurs during or immediately after a bowel spasm, it may be likely that as the spasm ceases, the catheter tip un-kinks, allowing urine flow to resume.

- Injecting a bladder washout solution into the bladder may not always confirm the presence of an occlusion. Frequently, this fluid may not immediately return, and the slow or delayed return may be due to a kinked catheter. Once sufficient fluid allows the catheter to become un-kinked, urinary flow resumes.

- When attempting to retrieve the bladder washout fluid using a 60 ml syringe, resistance is encountered on the syringe plunger. This may be due to a kinked catheter tip because if the catheter tip was not kinked, the suction associated with pulling on the syringe plunger would result in severe pain, and resistance would not be encountered.

- Some patients experience bladder catheter leakage during a bowel movement. This is the result of an increase in abdominal pressure against the bladder, which is likely to kink the catheter tip, thus forcing urine to bypass the catheter.

- Anecdotal: Two patients into whom indwelling bladder catheters were inserted with the tip slightly longer than current catheters began to experience severe leakage. The authors speculate that longer catheter tips kink more readily.

- Anecdotal: The bladder catheter of one patient was not draining at all. Different types and sizes of catheters had been tried unsuccessfully. When the balloon was deflated at regular intervals, about 600 ml of urine drained out. It is suggested that the catheter tip became un-kinked as the balloon deflated, allowing the catheter tip to migrate into another position and become un-kinked.

- Anecdotal: A patient on a catheter valve rather than a free drainage system was experiencing bypassing at the end of emptying the bladder. Because the bladder reduces in size while emptying, it kinks the catheter tip. A bladder contraction then results in leakage.

- It is unclear how the use of antimuscarinic drugs sometimes reduces catheter leakage. Perhaps by preventing detrusor contractions, these medications may relieve the pressure against the catheter tip. While this intervention decreased bladder leakage, the cause of bypassing remains unaddressed.

- Treating constipation prevents bypassing by reducing the abdominal pressure against the bladder, thus relieving the pressure on the catheter tip. This intervention also decreased urinary leakage but fails to treat the reason for urinary leakage.

- Another size, material, or brand of indwelling urinary bladder catheter may reduce the incidences of catheter leakage. This may be associated with the compliance of the catheter and/or the configuration of the catheter eyes and its natural position within the bladder.

**Potential Solution**

Based on the review of the literature and clinical experience, the authors hypothesize that one cause of urinary catheter leakage is catheter tip kinking, which results in the catheter “eyes” becoming occluded. The authors further hypothesize that by revising the catheter design, urine is free to drain, unrestrained. Revision of the indwelling bladder catheter should not include changing the catheter tip to a rigid material. Vaidyanathan, Huges, Mansour, and Soni (2008) stated that if the catheter tip was rigid and straight, it could puncture the bladder wall.

To facilitate drainage, the authors hypothesize that the original Foley-type urinary catheter be modified to include the placement of a third “eye,” or opening. This “eye” should be located on the catheter tip just below the two current “eyes,” yet above the balloon (see Figure 1). This modification should allow urine to flow without interruption. Although routine kinking of the catheter tip would continue to occur, this kinking would be at the level of the shaft where the two “eyes” are located. Placing the third “eye” below this junction would allow urinary drainage to continue, even in the presence of a catheter kink.

Another option may be to place a third “eye” on the catheter shaft just above the bladder neck. The section of the catheter shaft that contains this “eye” would remain inside the bladder (not inside the urethra) to provide continuous drainage. This intervention is theoretical because the current catheter balloon does not provide space for an additional “eye” in the right location. Yet, in theory, the placement of an “eye” below the catheter balloon but inside the bladder would allow debris to be drained from the base of the bladder and also prevent urine stagnation. Thus, if feasible, this modification may also reduce CAUTIs. Placement of this third “eye” would require a more radical redesign of the catheter bal-
loon or the development of another mean to anchor the indwelling catheter inside the bladder.

Conclusion

It is imperative for nurses and other health care providers who provide care for those with indwelling bladder catheters to have a clear understanding of the mechanism involved inside the bladder that result in occurrences of urinary leakage. The authors suggest a design change consistent with a new hypothesis. Clinical research needs to be performed to determine the effectiveness of this modified bladder design has in reducing the incidence of bypassing. Reducing bypassing by using evidence-based care for patients will improve their quality of life and decrease medical costs.

References


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