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Deflation of a Foley catheter balloon

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Abstract

Aim To investigate the changes in urethral and suprapubic catheter balloons following deflation and removal.
Method Observations were made on a selection of catheter materials, using three different deflation methods. Measurements were recorded before inflation and following deflation of catheter balloons.
Results The analysis identified that before inflation all catheter balloons were 1-2mm wider than the Charrière size. Following balloon inflation, five balloons were unchanged in appearance, four were slightly misshapen and the Coude balloon inflated at the side of the catheter shaft.
Conclusion The study has shown that manual syringe aspiration results in the formation of creases and ridges, and an increase in catheter balloon diameter size on deflation.
Self-syringe aspiration should not be used when deflating catheter balloons. It does not, however, cause the balloon membrane to collapse or become deformed.

CATHETERISATION HAS an important role in patient care and management for a variety of reasons, but where possible it should be avoided (Pellowe *et al* 2001, Pratt *et al* 2001). Having a catheter *in situ*, whether urethral or suprapubic, incurs its own problems (Evans and Feneley 2000, Lowthian 1989, 1998). Yet one area where there has been little research or investigation is in the changes that occur to the Foley indwelling catheter balloon once it has been deflated.

The most common way to deflate catheter balloons is by manual syringe aspiration, to remove the water from the catheter balloon. Using this method causes the balloon membrane to collapse and deform. This then results in crease and ridge formation occurring to the deflated balloon area. Another method of deflation is by self-syringe aspiration, as suggested by Semjonow *et al* (1995). However, self-syringe aspiration, as discussed later, is not recommended; it should not be used because there is no research to support the use of this method.

New versus old catheter balloon

Inspection of a new catheter balloon area, before inflation, shows that it is fairly flat and smooth. At insertion, the catheter's only function is to dilate the urethra. The greater the size of catheter – it is known as Charrière (Ch) size, for example 16Ch – the greater the dilation. Once the catheter is inside the urinary bladder and urine is draining, the catheter balloon has to be inflated using sterile water to the correct amount indicated on the packaging to keep the catheter *in situ*. Catheter balloon infill can vary between 2.5 and 5ml in paediatric catheters, 10 and 30ml in standard length and female length catheters, and between 30 and 80ml in specialised catheters used in urology units (Robinson 2001). The degree of distension of the balloon membrane depends on the volume of sterile water required to inflate the catheter balloon.

Before catheter removal, the water in the catheter balloon has to be drained. The catheter balloon has expanded and stretched at inflation, so following deflation, the balloon membrane collapses and deforms, resulting in surface changes to the deflated balloon. The higher the Charrière size and balloon infill – depending on the type of catheter material

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Key words

- Catheters
- Urinary catheters

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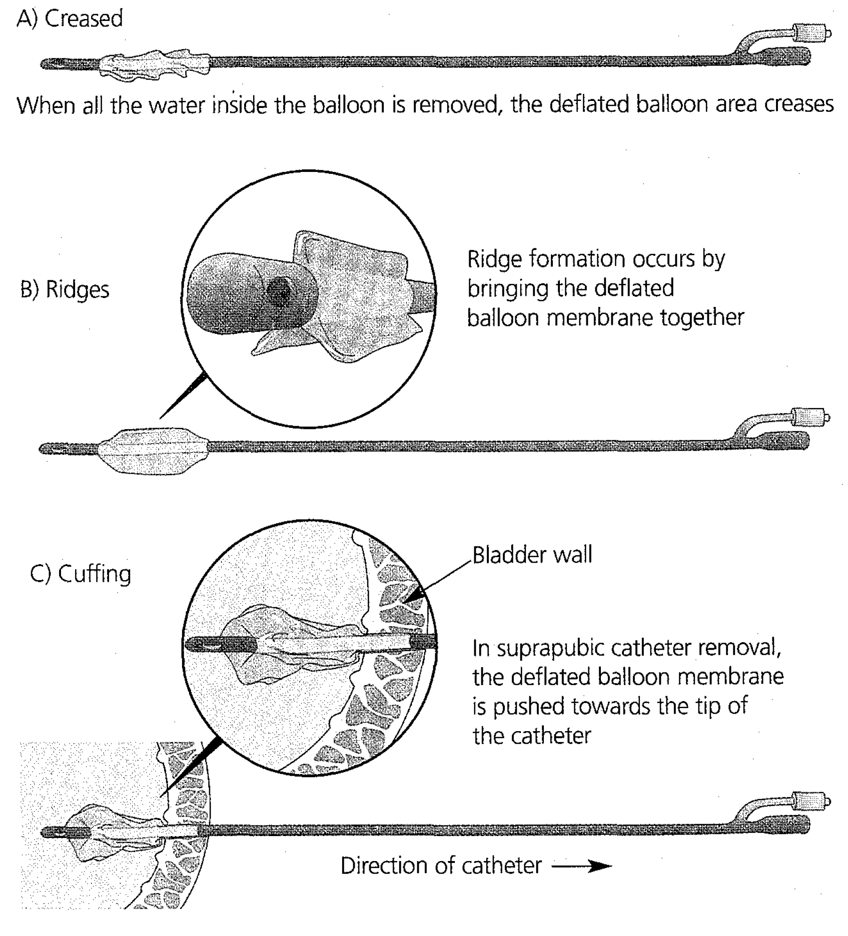
Figure 1. Changes that occur to indwelling catheter balloons on deflation at removal



used – the greater the changes, with a greater increase in diameter of the deflated catheter balloon area. When the catheter is being removed, the added balloon diameter causes further dilation of the urethra. The greater the increased diameter of the deflated balloon, the greater the degree of pain and discomfort patients may experience when catheters are removed; creases and ridge formation cause the deflated catheter balloon to exert pressure on the urethral wall. These changes can be seen clearly when inspecting the balloon area. Occasionally, when the catheter is removed, bleeding occurs and blood is seen coming from inside the urethra.

Catheter insertion

The two most common ways of inserting an indwelling catheter are urethral and suprapubic. Research shows that catheterisation and recatheterisation should be relatively painless. A local anaesthetic gel introduced into the urethra or suprapubic channel also acts as a lubricant, reducing surface friction between the catheter surface and urethral wall (Addison 1999, Colley 1997a, 1997b, Doherty 1999). No trials have been undertaken on the possibility of such a local anaesthetic gel having the same effect when removing indwelling catheters.

Catheter balloon changes

As mentioned previously, catheter balloons either crease or ridge, or cuffing occurs, when they are deflated (Figure 1):

- Crease: the balloon membrane collapses in on itself causing crease and ridge formation to occur.
- Ridges: at deflation the sides of the balloon membrane come together.
- Cuffing: as the catheter is removed via the bladder wall in suprapubic catheterisation, the balloon membrane is pushed back towards the catheter tip. This can be seen by pulling a deflated catheter balloon through your fingers and observing it moving towards the tip of the catheter.

Urethral catheter removal

Urethral catheter removal can sometimes be an unpleasant and painful experience. The distance a urethral catheter travels on removal can vary from 3.5 to 4cm in the female urethra and from 19 to 20cm in the male urethra (Blandy and Moors 1989). In the male, the deformed catheter balloon can be felt passing down the urethra, with some patients experiencing urethra discomfort. No trials have been undertaken on catheter removal using local anaesthetic gel.

Suprapubic catheter removal

Suprapubic catheters are removed via the bladder wall, then through the abdomen via a channel made surgically at initial insertion (Shah and Shah 1998).

Silicone catheters For suprapubic catheterisation Doherty and Winder (2000) suggested using 100 per cent silicone catheters, leaving the catheter *in situ* for a few minutes once the catheter balloon had been deflated. This is to allow the silicone balloon to return to its original state. Following this suggestion, a 100 per cent silicone catheter due for change was left *in situ* for five minutes following balloon deflation. Resistance was felt on removing the catheter. On inspection, the catheter balloon area had not returned to its original state. It had cuffed, and the balloon membrane had been pushed towards the catheter tip and folded over. In another investigation, 100 per cent silicone catheter was deflated, removed and the balloon was found to have ridge formation. The catheter was then left for 30 minutes outside the body, but it failed to return to its original state.

The Medical Devices Agency has highlighted its concern over the removal of 100 per cent silicone catheters used in suprapubic catheterisation (MDA 2001). The report was concerned about the pain and discomfort patients suffer when using this type of catheter material due to cuffing of the deflated catheter balloon on removal. At present, only 100 per cent silicone catheters can be used to catheterise patients who are allergic to latex either urethrally or suprapubically. Patients who are not allergic to latex have a larger choice of catheter to choose from, both latex and non-latex materials (Woodward 1997). In the author's experience when removing suprapubic catheters, no matter which catheter material is used, some resistance is felt as the catheter is being removed, but not all catheter materials incur a cuffing effect. Because it is not possible to see how the bladder wall (detrusor) reacts when removing suprapubic catheters, discomfort could be due to the catheter balloon becoming deformed on deflation, and to the increase in diameter size of the balloon resulting from inflation. The bladder wall might be stimulated as the catheter is being removed, causing the balloon to be pushed towards the tip of the catheter. Another problem with suprapubic catheters is overgranulation of tissue at the entry site on the abdomen. Overgranulation could also occur at the bladder wall as a result of the body trying to heal and attach itself to the catheter. The only way this can be proved is to carry out a cystoscopy and examine the catheter inside the bladder before and following deflation, and observe what is occurring when the catheter is being removed.

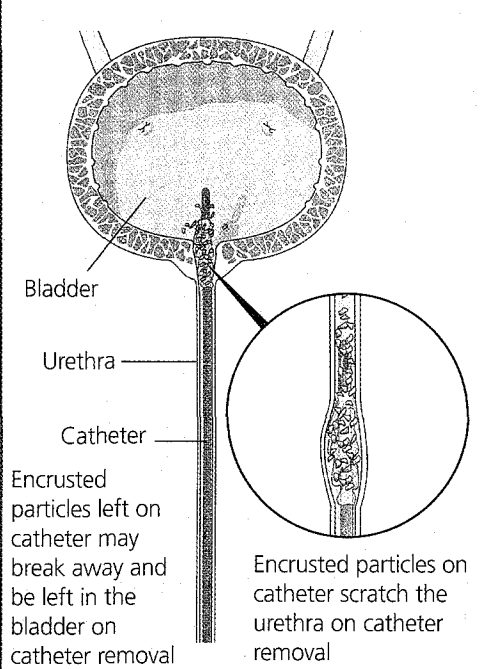
Encrustation

Encrustation of indwelling catheters, which in time can cause blockage, is best dissolved before catheter removal, using one of the commercially available acidic instillations designed for this purpose (Getliffe 1996, Rew 1999). When an encrusted catheter balloon is deflated without using an acidic instillation, non-dissolved particles of encrustation may still be attached to the deflated catheter balloon and catheter tip. When removing the catheter, particles may break away and be deposited inside the urinary bladder. Over time, these will produce bladder stones and require treatment (Steggall 2001), or may scratch the delicate urethral lining breaking away from the catheter leaving particles inside the urethra. Particles left inside the urethra cause further injury when recatheterisation is required, which can lead to bleeding, infection, scarring and stricture formation (Figure 2).

Examination of catheters

Pre-inflation A selection of ten catheter materials was used in this investigation. Pre-filled catheters were excluded because of the already infilled water stretching the catheter infill valve area. Pre-filled catheters when new may have 10ml water in the secured balloon infill chamber. However, over a period of time, some pre-fill catheters do not appear to have the original infill needed due to slow evaporation of the already infilled valve area. To take balloon measurements, the exact amount of sterile water used to inflate the catheter balloons had to

Figure 2. Encrustation of indwelling catheters



be accurate. This is why pre-filled catheters were excluded from this investigation. No research has been undertaken on the amount of sterile water already in pre-filled catheters as to the amount of water lost over a period of storage time prior to being used for catheterisation. Seven of the catheters used were soft Foley catheters. These are used most commonly in community and hospital settings. These are:

- Polytetrafluroethylene (PTFE).
- Silicone-elastomer.
- Hydromer-polymer.
- 100 per cent silicone.
- Hydrogel.

The remaining three catheters were specialised, stiffened type catheters used in urology units, comprising Coude, round-tip and Couvelaire (haematuric/prostatic) catheters. These were used to compare the difference between soft Foley catheter materials and hardened materials. Later in the trial, four hydrogel-reinforced urological catheters were also included – these were inserted in theatre and were measured following removal on the urology ward three to four days post-operatively.

Measurements for the ten catheter materials were made before inflation to the (Table 1):

- Diameter of the shaft of catheter.
- Length of the pre-infilled catheter balloon.
- Diameter of the pre-infilled catheter balloon.

Measurements of balloon area The unused catheters with their pre-inflated balloon area were placed next to the flat edge of a fixed carpenter's square. A fine pin was then placed on the opposite side of the balloon area. Measurements were taken between these two areas to the nearest millimetre. To ensure accuracy, each measurement was repeated twice. Each catheter balloon was then

Table 1. Measurements of pre-inflated catheter balloons

Catheter material	Charrière size (Ch/mm)	Balloon infill (ml)	Balloon length (mm)	Pre-inflated balloon diameter (mm)
PTFE	14/4.7	10	10	6
Hydrogel	12/4.0	30	25	5
Hydrogel	14/4.7	10	20	6
Hydrogel	16/5.3	10	15	7
Silicone-elastomer	16/5.3	10	20	7
Hydromer-polymer	16/5.3	10	20	8
100% silicone	16/5.3	10	15	8
Coude	14/4.7	30	35	6
Round-tip	18/6.0	30	38	8
Couvelaire	20/6.7	30	38	8

inflated using sterile water to the correct amount as indicated on the catheter packaging and infill valve. Following inflation, each balloon was observed for its inflated shape and the inflated balloon diameter was measured. All catheters were then left for seven days (Table 2).

Measurements following deflation Deflation of the catheter balloon was performed in three different ways:

- Self-syringe aspiration: the syringe plunger was left to move by itself to deflate the catheter balloon. Only a short gentle pullback was used to start the movement.
- Manual syringe aspiration: the commonest way in which catheter balloons are deflated, by pulling back on the syringe plunger to remove the water from the catheter balloon.
- Cutting off the inflation valve: although this method was used in the past to deflate catheter balloons, it should not be used because of the risk of causing the fine infill channel to seal which will make deflation difficult.

Using these three methods, observations were made on:

- The volume of water aspirated.
- The volume of water left *in situ* in the catheter balloon.
- Diameter measurements of the deflated catheter balloon.
- Whether or not the surface of the deflated catheter balloon had changed with the formation of creases or ridges.

Table 2. Measurements of inflated catheter balloon

Catheter material	Diameter of inflated balloon (mm)	Balloon shape
PTFE	25	Rounded
Hydrogel	30	Misshaped
Hydrogel	25	Misshaped
Hydrogel	25	Rounded
Silicone-elastomer	26	Rounded
Hydromer polymer	27	Rounded
100% silicone	25	Misshaped
Coude	30	Formed to side of catheter
Round-tip	38	Rounded
Couvelaire	37	Misshaped

Results

On average, before inflation, all catheter balloons were found to be 1-2mm wider than the actual Charrière size identified on the packaging or valve (Table 1). Following balloon inflation, five balloons were of a normal round appearance, four were slightly misshaped, but the Coude balloon inflated at the side of the catheter shaft.

Self-syringe aspiration Using this method to deflate the catheter balloon (Table 3), the syringe plunger was given a gentle start. The syringe was then allowed to deflate the balloon itself until the plunger stopped moving. The volume of water removed was recorded.

Using this method, none of the soft Foley catheters produced crease or ridge formation and the balloon area was slightly oval in shape. The remaining water left inside the catheter balloons varied between 0.75 and 1.5ml. However, the 100 per cent silicone catheter balloon also lost 2.5ml water by balloon diffusion during the seven days after removal. This type of catheter material is prone to balloon diffusion, in that the infilled water slowly passes through the balloon membrane (Pomfret 1996, Robinson 2001). Using this method, all the soft Foley catheter balloon diameters also increased in size between 1 and 3mm. The three specialised catheters (Coude, round-tip and Couvelaire) did not respond using this method.

Semjonow *et al* (1995) suggested that 0.5ml sterile water should be reinserted into the catheter infill channel and balloon following deflation, to reduce the risk of trauma inside the urethra on catheter removal (Figure 3). When this amount of sterile water was inserted, crease and ridge formation were removed, and the deflated catheter balloon gained a slight oval shape, as suggested by Semjonow *et al* (1995). In theory, this then acted as a cushion between the catheter balloon surface and urethral wall on catheter removal. However, no research evidence could be found to support this idea. Catheter inflation valves are designed for single inflation and single deflation only. Therefore, this method of catheter balloon deflation and catheter removal should not be undertaken because of the risk of trauma due to the catheter balloon not being fully deflated.

In the investigation, it was found that when 0.5ml water was reintroduced into the deflated catheter balloon after using manual syringe aspiration, the creases and ridges disappeared, and the catheter

Table 3. Balloon deflation by self-syringe aspiration

Catheter	Self-syringe aspiration (ml)	Water left *in situ* (ml)	Deflated balloon diameter (mm)	Differential diameter (mm)	Crease or ridges
PTFE	8.5	1.5	7	+1	none
Hydrogel	8.5	1.5	8	+3	none
Hydrogel	9.0	1.0	7	+1	none
Hydrogel	9.2	0.75	8	+1	none
Silicone-elastomer	8.5	1.5	9	+2	none
Hydromer-polymer	8.75	1.25	10	+3	none
100% silicone	6.5*	1.0	10	+2	none
Coude	did not respond to self-syringe aspiration				
Round-tip	did not respond to self-syringe aspiration				
Couvelaire	did not respond to self-syringe aspiration				

* Lost 2.5ml in 7 days by balloon diffusion

balloon formed a slight oval shape, as Semjonow *et al* (1995) stated, but only in the soft Foley catheters. In the specialised catheters, however, up to 4ml water was required. The creases and ridges did not disappear in these catheters and no oval shape formed until the catheter balloon started to re-inflate.

Manual syringe aspiration This is the most common method used to deflate catheter balloons. Using this method a different picture emerged (Table 4). By pulling back on the syringe plunger to remove the infilled water from the catheter balloon, the balloon membrane and balloon inflation valve area collapsed and deformed. This resulted in crease and ridge formation to the deflated balloon and also an increase in the diameter of the deflated balloon of between 1 and 4mm (soft Foley catheters) and between 2 and 5mm (specialised catheters).

Following the trials of balloon deflation using self-syringe and manual syringe aspiration, all ten catheter balloons were re-inflated and left for a further 24 hours. This time all the catheter balloon inflation valves were cut off. When all the infilled water had drained away, the catheter balloons developed creases and ridges, as if manual syringe aspiration had been used.

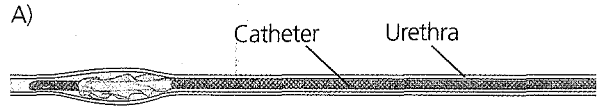
Post-operative catheters A local urology ward was approached and asked whether measurements could be taken of catheters inserted in theatre which were removed post-transurethral resection prostatectomy (Table 5). A member of staff volunteered and was instructed on how to take these measurements. Working on the basis that the unused catheter balloon diameter was 1-2mm wider than the Charrière size, deflation was carried out using manual syringe aspiration. On inspection ridge formation had occurred, with an increase in the diameter of the deflated catheter balloon area of between 4 and 5mm.

Measurements were then undertaken to find out how soon after balloon inflation such changes occur and a long-term catheter was examined following removal after 10-12 weeks *in situ*. In the first exercise, a new hydrogel 14Ch/4.7mm, 10ml balloon infill was measured before inflation. The pre-filled diameter of the balloon was 6mm. This indicated a 1.3mm increase in its diameter, working on the finding that catheter balloons prior to inflation are 1-2mm wider than the Charrière size indicated on the catheter/packaging as previously mentioned.

The balloon was inflated with 10ml sterile water. After 30 seconds the balloon was deflated using self-syringe aspiration and 9.75ml water was then aspirated. The deflated balloon was slightly oval in shape with no crease or ridge formation. The remaining 0.25ml was removed using manual syringe aspiration. One slight crease formation appeared with the catheter balloon diameter measuring 7mm, an increase of 1mm.

Figure 3. Reducing the risk of trauma on catheter removal

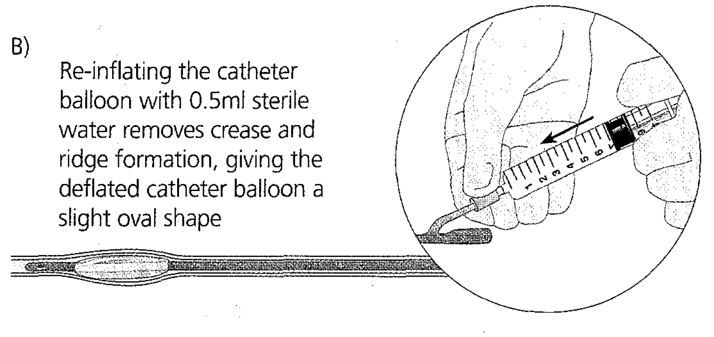
A)



Deflating the catheter balloon completely results in crease or ridge formation

B)

Re-inflating the catheter balloon with 0.5ml sterile water removes crease and ridge formation, giving the deflated catheter balloon a slight oval shape



(Semjonow *et al* 1995)

Table 4. Balloon deflation by manual syringe aspiration

Catheter	Manual syringe aspiration (ml)	Deflated balloon diameter (mm)	Differential diameter (mm)	Creases or ridges
PTFE	10	7	+1	2 ridges
Hydrogel	30	9	+4	1 ridge
Hydrogel	10	8	+2	1 ridge
Hydrogel	10	9	+2	2 ridges
Silicone-elastomer	10	8	+1	Creased
Hydromer-polymer	10	10	+2	3 ridges
100% silicone	10	9	+3	Creased
Coude	30	8	+2	2 ridges
Round-tip	31	10	+2	4 ridges
Couvelaire	30	13	+5	2 ridges

Table 5. Post-operative balloon measurement (using manual syringe aspiration)

Catheter material, Charrière size/mm and balloon infill	Deflated balloon diameter	Differential diameter (mm)	Creases or ridges
Hydrogel-reinforced 24Ch/8mm 20ml	14mm	+4	5 ridges
Hydrogel-reinforced 24Ch/8mm 40ml	15mm	+5	3 ridges
Hydrogel-reinforced 24Ch/8mm 20ml	15mm	+5	3 ridges
Hydrogel-reinforced 24Ch/8mm 20ml	14mm	+4	2 ridges

NB.These figures are based on the pre-filled balloon diameter being 2mm wider than the catheter diameter. These catheters were inserted in theatre and removed on the ward three to four days post-operatively.

In the second exercise a hydrogel 16Ch/5.3mm with an original 10ml balloon infill was removed after 10 weeks *in situ*. Using self-syringe aspiration, 8.5ml was removed. In theory this meant that 1.5ml remained *in situ*. Using manual syringe aspiration, only 1ml was aspirated, indicating that 0.5ml was lost over this ten-week period. Two ridges were present and the deflated catheter balloon diameter was 10mm, a 3mm increase.

Conclusion

Catheter balloons undergo changes when deflated. However, one method of deflation, self-syringe aspiration, does not cause the balloon membrane to collapse and deform. Once deflated, the catheter balloon developed a slight oval shape due to a small volume of water left in the balloon and infill channel which could then (in theory) have a cushioning effect between the catheter balloon and urethral wall. However, no trials have yet been undertaken on the use of this method and so self-syringe aspiration is not recommended.

Manual syringe aspiration, the most common method of deflating catheter balloons, results in crease and ridge formation because there is no water left inside the balloon and infill channel. This causes an increase to the diameter of the deflated balloon. The greater the Charrière size and balloon infill and type of catheter used, the greater the diameter of the deflated balloon. On catheter removal these ridges could dig into the delicate urethral lining causing trauma. Occasionally, bleeding is observed from the urethra when catheters have been removed, indicating a degree of trauma inside the urethra due to changes to the deflated catheter balloon caused by crease or ridge formation and if encrustation is still attached to this area. To reduce trauma and bleeding to the urethra and suprapubic channel, following balloon deflation using manual syringe aspiration, catheters should be removed slowly and gently, not pulled out quickly, especially if an increase in the deflated balloon is apparent due to crease and ridge formation

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