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# Flow Characteristics of Urethral Foley Catheters

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Summary. The flow, which reflects the effective internal diameter of the catheter, was measured in urethral catheters. Water immersion did not reduce the flow. Siliconized Latex catheters had a high frequency of function failure and the lowest flow. The siliconized Latex and PVC catheters showed an overlapping in flow for catheters of different sizes. A linear increase in flow with increasing size was found with the smaller sizes. The flow in this system represents the internal catheter diameter, which does not always parallel the Charriere number. Silicone catheters were found to have the highest flow with a linear relationship between flow and size. On the basis of this study a catheter with Charriere 24 is recommended for the relief of obstruction, whereas Charriere 12 - 14 is adequate when the indication is simple urinary drainage.

Key words. Catheter - Urinary flow - Latex - Polyvinyl chloride.

## INTRODUCTION

The urethral mucosal reaction caused by an indwelling catheter is made worse by increasing the diameter of the catheter, although it can be minimised if materials such as silicone are used.

A smaller diameter increases the risk of obstruction. The ideal would be an inert material with a high ratio between inner and outer diameter. The flow allowed through an ordinary unobstructed catheter is many times higher than the physiological flow of urine, but at the low pressure occurring in the bladder, a localized partial obstruction causes a significant flow reduction. This is especially true if the urine is viscous, as in purulent cystitis or in the presence of debris or bleeding. The diameter might also be reduced by the water absorption known to occur in the catheter. As the flow through the catheter is proportional to internal diameter 2-4 at the narrowest point of the lumen, a flow measurement provides information of the effective lumen diameter.

Different materials have been used to find the best catheter. This study measured the catheter flow in a low pressure system before and after immersion in water in an attempt to demonstrate differences between catheters of different materials.

## MATERIALS AND METHODS

Three types of catheters were investigated:

1. Siliconized Latex with Nelaton tip (Folicon, Eschman Bros. and Walsh Ltd).
2. Polyvinylchloride catheters with Thieman tip (Simplastic J. G. Franklin and Sons).
3. Silicone catheters with Nelation tip (Silicath, Travenol Laboratories Ltd).

The method used to study the flow is shown in Figure 1. The volume and surface area of the re-

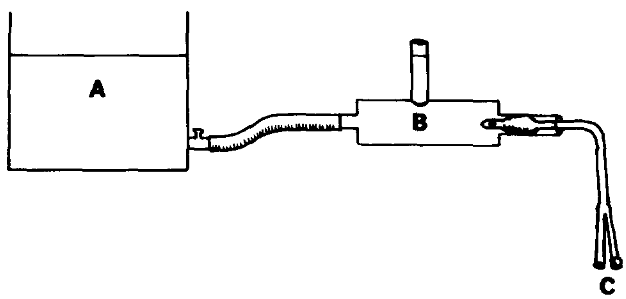


Fig. 1. Method for measuring the flow through the catheters. A Reservoir. B Transparent chamber with a tube for pressure equalization. C Catheter

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servoir were large enough to keep the pressure at the tip of the catheter between 6 and 8 mm water even at the high flows obtained with the larger catheters. The catheter was kept in place during the measurement by gently filling the ballon with air after placing it in the transparent chamber. The water flowing out of the catheter during one minute was measured (ml/min).

After making ten measurements in nine catheters of the same size (16 Ch), we estimated the methodological coefficient of variation (C.V.) with the formula:

$$C.V.\ (\%) = \frac{\text{Standard deviation}}{\text{mean}} \times 100.$$

The flow was measured in ten PVC and ten Latex catheters and two silicone catheters of each size. The number of silicone catheters was restricted by cost. Each catheter was measured twice, and the catheter was placed vertically as demonstrated in Figure 1. Two catheters of each and material were soaked in water, the flow measurements being repeated after one, seven and 21 days in water. In two other examples of each size and catheter material, the flow was estimated with the catheter placed horizontally in relation to the transparent chamber.

## RESULTS

The mean methodological coefficient of variations was found to be 2,9% (1,0, 2,4, 3,2, 2,6, 2,5, 6,0, 2,5, 2,9, and 2,9%).

Table 1 lists the results of the flow measurements. The expected gradual increase in the flow with increasing size is seen, the increase being almost linear except for Latex and PVC Charriere 24 where there was an even more marked increase in flow. The highest flow was obtained with the silicone catheters where the flow in-

Table 1. Flow through catheters placed vertically

| Charriere gauge | Siliconized latex catheter Mean flow[x] ml/min | Siliconized latex catheter Flow range ml/min | PVC catheter Mean flow[x] ml/min | PVC catheter Flow range ml/min | Silicone catheter Mean flow ml/min | Silicone catheter Flow range ml/min |
|---|---|---|---|---|---|---|
| 12 | 60 ± 6 | 59 - 68 | | | | |
| 14 | 130 ± 9 | 107 - 136 | 160 ± 24 | 120 - 200 | 270 | 260 - 270 |
| 16 | 205 ± 44 | 120 - 250 | 285 ± 24 | 248 - 310 | 360 | 360 - 360 |
| 18 | 320 ± 9 | 308 - 335 | 325 ± 13 | 312 - 355 | 570 | 540 - 600 |
| 20 | 355 ± 59 | 305 - 455 | 520 ± 54 | 446 - 620 | 690 | 680 - 700 |
| 22 | 455 ± 53 | 420 - 605 | 620 ± 36 | 580 - 680 | 960 | 960 - 960 |
| 24 | 900 ± 100 | 605 - 960 | 950 ± 57 | 873 - 1035 | 1165 | 1160 - 1170 |

x mean ± sd

Table 2: Catheter function failure after immersion in water; two specimens of each size and material

| | Siliconized latex catheter | PVC catheter | Silicone catheter |
|---|---|---|---|
| Initial measurement | 2 with 50% flow reduction<br>2 obstructed<br>1 with leakage from the ballon | 2 with 50% flow reduction | 1 with obstruction |
| After water immersion | | | |
| 1st day | 3 more obstructed | | |
| 7th day | 2 more obstructed much or all of the silicone was gone | 1 with damaged ballon | |
| 21st day | 1 with obstruction of the balloon canal? All the silicone was gone | 1 with leaking balloon | |

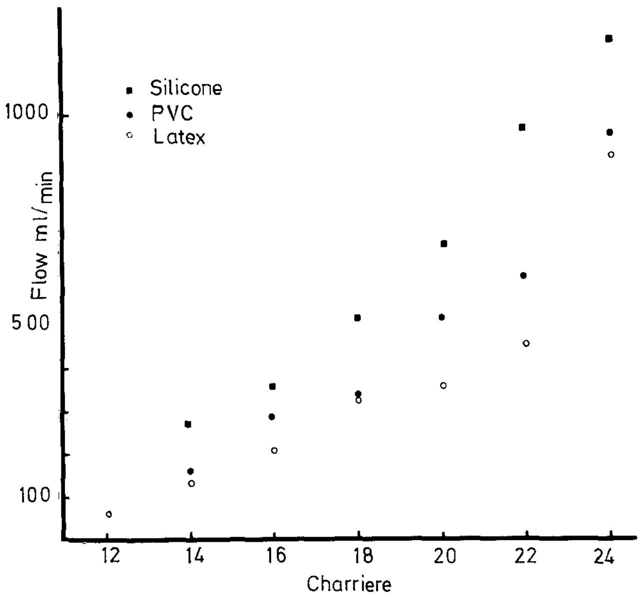


Fig. 2. Flow in ml/min in urethral catheters of different materials and of different sizes

Table 3. Reduction in flow with catheter placed horizontally

| | |
|---|---|
| PVC-catheter | 51 - 57% |
| Siliconized Latex catheter | 41 - 50% |
| Silicone-catheter | 43 - 53% |

crease was linear for all the sizes investigated. The overlapping of the flow ranges and the considerable variation in the range between different sized catheters of the same material is to be noted. Figure 2 graphically demonstrates the mean flow.

One, seven, and 21 days immersion in water gave no change in flow.

The siliconized Latex catheters were often malfunctioning, (Táble 2). After 21 days of water immersion 5 out of 14 were faulty.

Table 3 shows the decrease in flow obtained with the catheter placed horizontally.

## DISCUSSION

Modern urethral catheters use three different materials:

1. Latex. The traditional material with a siliconized or teflonized surface.
2. Silicone. The catheter is made of silicone, a material with a well-known low foreign body effect.
3. Polyvinylchloride, PVC. A more firm catheter suitable for use with a Thieman tip in patients where prostatic enlargement makes catheterization difficult.

The Charriere size denotes the external circumference (in mm) of the catheter but catheters of the same Charriere gauge but made of different materials can have different internal diameters. As the flow through the catheter is proportional to the internal diameter [2-4] at the narrowest point of the lumen, a flow measurement provides relevant information of the effective lumen diameter. Such information cannot easily be given by measuring the cross sectional area of the catheter as it could differ through the length of the catheter.

The flow was highest for the silicone catheters. The increase in flow was linearly dependent on increasing size. The Latex and PVC catheters gave a somewhat lower flow, the flow increase with increasing size being linear except for Charriere 24, where the flow markedly increased. This effect is especially obvious for Latex catheters where the substitution of a Charriere 18 with 22 or 24 gives an increase in flow of 42 and 180 per cent respectively.

The increase in flow between the smaller catheters is more limited and in some instances minimal. The wide range also gives an overlapping effect. As Table 1 shows, the use of a Latex catheter of Charriere 16 instead of 14 does not necessarily give a higher flow; the same effect can be seen for PVC of Charriere 18 compared with 16. It is therefore essential to know the flow characteristics of the individual catheter to avoid the use of an unnecessarily large size. The flow represents the functional internal diameter of the catheter, and our results show that this diameter cannot be concluded from simple measurement. From flow characteristics, it can be concluded that a Charriere of 14 or perhaps less should be used to minimize the traumatic effect on the urethral mucosa. PVC and siliconized Latex catheters of Charriere 16 to 22 are of limited value when drainage is the major indication for catheterization. This conclusion confirms clinical experience (1).

Immersion in water did not decrease the flow but gave a large number of functional failures with the Latex catheters. Moreover, the silicone covering was lost, resulting in an increased irritation in vivo. The marked reduction in flow in horizontally placed catheters emphasizes the need to keep the catheter bag below the bed and not in it.

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