Urol Res (1990) 18:159–163

Urological Research

An experimental technique for renal intrapelvic access

P. C. Ryan[1,2], H. McAllister[3], and J. M. Fitzpatrick[1,2]

[1]Department of Urology, Meath Hospital, Dublin, [2]Department of Experimental Surgery, Trinity College Dublin, and [3]Department of Radiology, Veterinary College, Dublin, Ireland

Accepted: March 9, 1989

Summary. This study describes an experimental technique for insertion of an indwelling cannula into the canine renal pelvis, and demonstrates its use in the measurement of pelviureteric pressure and motility, creatinine clearance, Whitaker tests, nephrostograms and nephrostomy drainage. The system, which consists of cannula, Heplock and plastic fixation disc, has been inserted into 53 canine kidneys (48) dogs, and percutaneous needle passage into the subcutaneously placed Heplock was used to gain access to the renal pelvis. This technique was successful in virtually all cases (131 separate procedures), and there were few complications. The indwelling intrapelvic cannula is a simple, cheap and reliable method of gaining longterm renal intrapelvic access in the dog, and has many experimental applications.

Key words: Renal – Experimental – Nephrostomy

The ability to perform serial measurements and tests under standard conditions and with minimal invasion is a prime objective in designing useful experimental models. It is also crucial that any indwelling system designed for repeated use should not itself have any significant effect on the indices under observation.

Chronic access to the upper urinary tract has proven to be a difficult technical problem in experimental urology. The desire to monitor intra-ureteric or intrapelvic pressure and motility has in some cases led to the introduction of catheters passed in retrograde fashion into the ureter or renal pelvis [2, 4, 8, 10]. These techniques were suitable for acute experiments only. The use of a nephrostomy tube has been described for intrapelvic pressure monitoring [9] and later Schweitzer et al. devised a means of performing pressure measurements within the renal pelvis on a long-term basis using intermittent percutaneous puncture of an indwelling cannula [7].

This paper describes a technique for insertion of an indwelling cannula into the canine renal pelvis and demonstrates a number of experimental applications of the cannula. The technique is a modification of that described by Schweitzer et al. [7].

Materials and methods

Access to the renal pelvis has been obtained in 53 adult male mongrel canine upper urinary tracts by the insertion of an indwelling intrapelvic cannula. The operations were performed under general anaesthesia via a subcostal loin incision with the animal lying on its side. The 3 muscle layers are split in the line of the muscle fibres and the peritoneum opened to expose the renal cortex. The majority of operations (40) were performed on the left kidney which can be delivered into a subcostal incision without any further dissection. A small incision is then made in the peritoneum overlying the renal hilum anteriorly and the upper ureter exposed by blunt dissection.

The kidney is positioned with the cortex facing upwards (hilum downwards) and, having made a very small incision in the mid point of the cortex, a 6Ch dilator is introduced through the renal cortex and medulla until it is visualised in the ureter. A guide wire is then passed and the track enlarged up to 10Ch using serial dilatation.

The indwelling cannula apparatus consists of an intramedicut 14G long-line cannula, which has been shortened to 20 cm long, introduced through a central hole in a disc approximatel 1.5 cm in diameter, cut from semi-rigid inert plastic (Fig. 1). The disc has six peripheral holes to permit passage of sutures. The central hole in the disc should provide resistance to movement of the cannula but not obstruct its lumen. The cannula is introduced down the renal cortical track until it is just palpable in the renal pelvis by a finger placed in the hilum of the kidney. The disc is then placed at a point on the cannula where, when sutured to the renal capsule, it will maintain the cannula positioned in the pelvis.

The cannula is then withdrawn from the kidney and a silk ligature is placed on either side of the disc around the cannula to maintain this placement of the disc. The cannula is repositioned in the renal pelvis via the cortical track and the disc is sutured down to the renal capsule with 3/0 silk ligatures, using four of its peripheral holes. The tip of the tube is now fixed in the renal pelvis and draining urine.

The luer end of the cannula is then brought through the abdominal wall musculature of the upper wound flap in the mid axillary line and the plastic disc sutured to the lateral abdominal wall using the two remaining holes. In this way, the renal cortex is fixed to the lateral abdominal wall and postural movements of the kidney, which might dislodge the cannula after the animal awakes, are prevented.

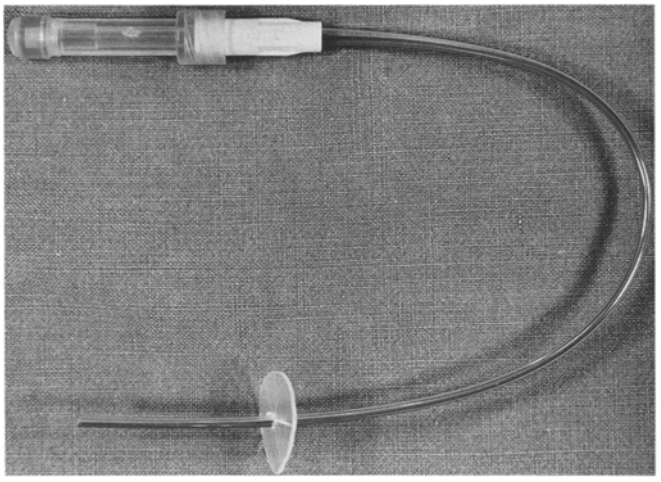

Fig. 1. Chronic indwelling cannula: apparatus. The cannula (shortened to 20 cm), plastic disc with peripheral holes, and Heplock are shown. The Heplock has a rubber diaphragm covering the unattached end which permits passage of a needle into the lumen of the Heplock

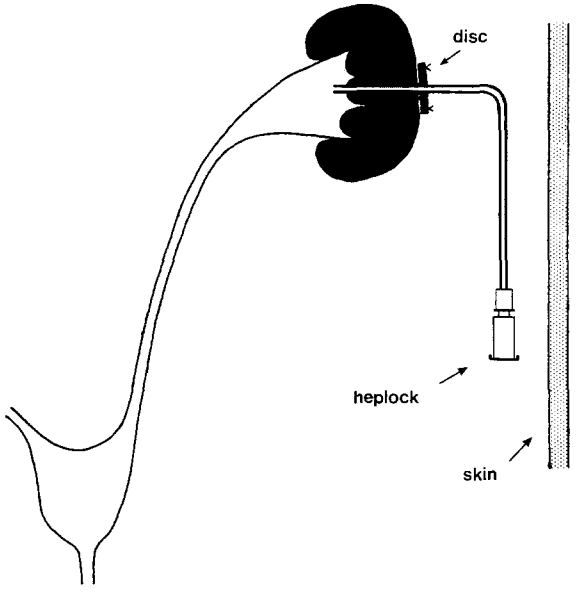

Fig. 2. Chronic indwelling cannula: placement. Catheter tip is positioned in the renal pelvis. The plastic disc which is sutured to the renal capsule secures the position of the cannula in the renal pelvis. Subcutaneous Heplock attached at the luer end enables percutaneous needle puncture to obtain renal pelvic access

Table 1. Results of intrapelvic pressure, creatinine clearance and Whitaker tests one month following cannula insertion ($n=5$). No significant difference between pre and post cannula intrapelvic pressures, creatinine clearances or Whitaker test results (Paired t test). Standard errors are shown in brackets

	Day 0	Day 30
Mean intrapelvic pressure (mm Hg)	4.8 (1.4)	6.1 (1.5)
Mean creatinine clearance (ml/min)	50.4 (3.8)	52.3 (4.1)
Mean provoked pressure	11.2 (3.2)	12.4 (3.6)

Table 2. Number of canine upper tracts to which each procedure was applied

Procedure	Number of upper tracts
Pressure/mortility measurement	53
Whitaker test	46
Nephrostogram	21
Nephrostomy drainage	12

Finally, a Heplock is attached to the luer end of the cannula and screwed tightly into position. The cannula and Heplock are tunnelled subcutaneously and positioned under the skin on the dog's back to lie close to the vertebral spinous processes in the loin. A transcutaneous nylon suture maintains this position (Fig. 2). The subcostal wound is then closed. Intramuscular antibiotic prophylaxis is commenced pre-operatively and maintained for 3 days following surgery (Amoxycillen 250 mg twice daily, Streptomycin 500 mg twice daily).

Whenever access to the renal pelvis was subsequently required, the skin over the subcutaneously-positioned Heplock was shaved and rigorously prepared with antiseptic solution. An 18G needle was passed through the skin to enter the Heplock via the rubber diaphragm. Passage of urine was then awaited, and if this did not occur spontaneously, the cannula was flushed with 1 ml of isotonic Nacl.

As soon as position in the renal pelvis was confirmed by efflux of urine, the appropriate test or measurement was carried out. This procedure could be performed with or without sedation as appropriate to the test required.

The indwelling cannula has been inserted into 53 canine kidneys (48 dogs) and the incidence of complications, reliability of intrapelvic access, and uses of the cannula have been assessed for experimental periods of up to 3 months. In 5 animals, the effects of the cannula alone on pelviureteric pressure and motility and on renal function (creatinine clearance) have been measured and the Whitaker test used to detect possible obstruction. Pelviureteric pressure and motility were measured by connecting the percutaneously placed needle to a standard pressure transducer and pen recorder. Creatinine clearances was compared before and 30 days following cannula insertion by measuring urine output, creatinine and serum creatinine over 3 separate 20 min periods. The average of the three tests was taken to be the creatinine clearance. The Whitaker test was applied at the beginning and end of the 30 day insertion period. The standard flow rate of 10 ml/min was perfused and provoked pressures measured (Table 1).

In a number of other experiments, the cannula has been used to perform a range of tests and techniques, and these applications are reported here. These have included pressure and motility assessments, Whitaker tests, nephrostograms and nephrostomy drainage (Table 2).

Results

The insertion procedure and long-term presence of the indwelling cannula were well tolerated and complications were few. Pyonephrosis did not occur as a complication of insertion or the presence of the cannula. No gross or histological abnormality was noted in kidneys removed after the cannula had been in situ for 3 months and encrustation or blockage of the cannula was not observed ($n=7$).

Renal intrapelvic access was attempted a total of 131 times in 53 indwelling cannulas. Urine was obtained on passage of the needle into the Heplock in 96% of cases. In

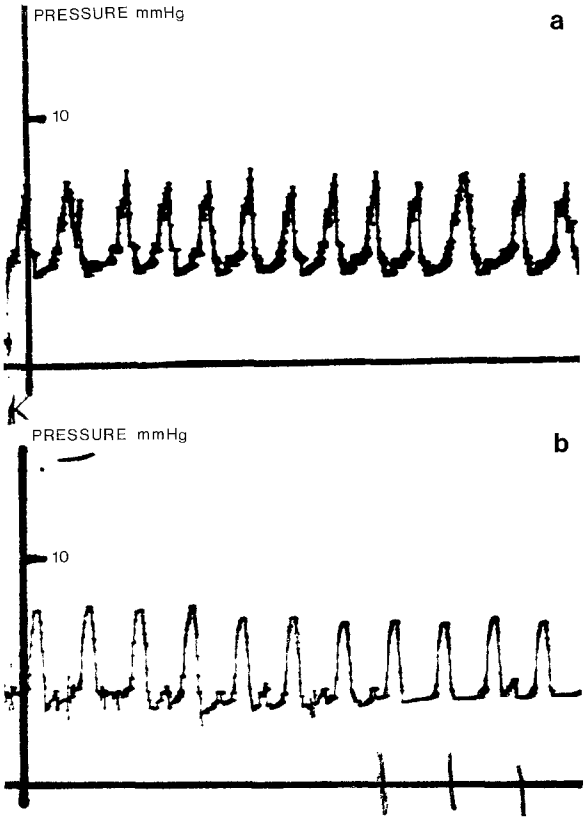

Fig. 3a and b. Chronic indwelling cannula: effects on pelvi-ureteric motility and intrapelvic pressure. **a** Normal pelvi-ureteric motility at the time of cannula insertion. **b** Pelvi-ureteric motility one month following intra-pelvic cannula insertion is essentially unchanged from pre-operative tracing. Intrapelvic pressure is not significantly affected

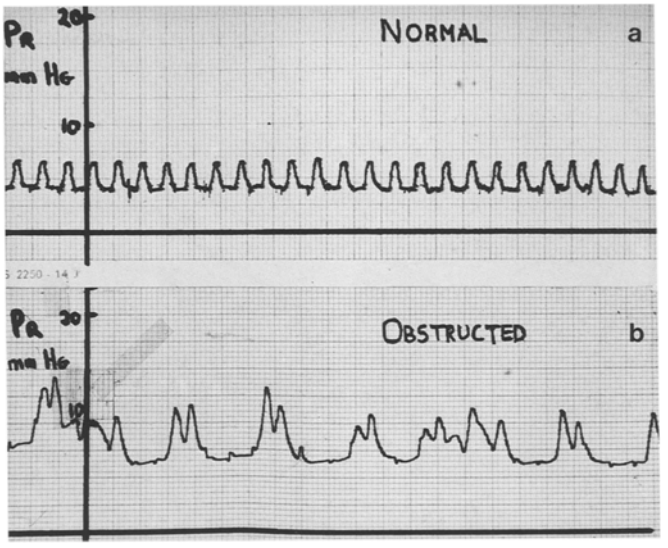

Fig. 4a and b. Pelvi-ureteric motility in ureteric obstruction. **a** Normal pelvi-ureteric peristaltic pressure waves. **b** Disorganization of peristalsis in a chronically obstructed ureter

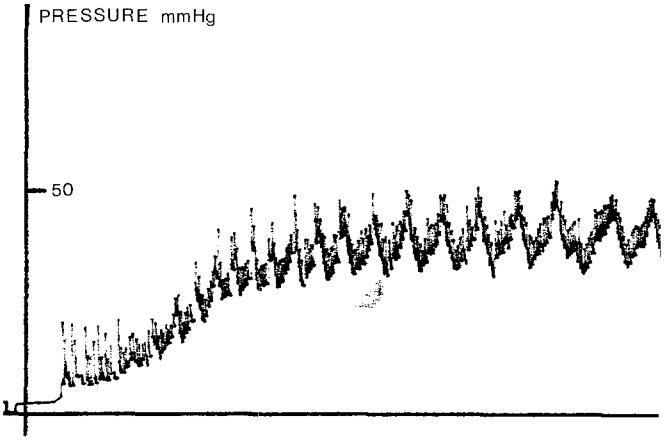

Fig. 5. Whitaker test. Intrapelvic pressure tracing during a Whitaker test: as perfusion (10 ml/min) commences, the pressure rises sharply until it reaches the plateau level (provoked pressure). This tracing is from an obstructed upper tract

the remaining 4%, urine flowed immediately following the saline flush, with the exception of one dog where the cannula failed. Subsequent exploration revealed that the cannula had become dislodged from the kidney, which had fallen away from the lateral abdominal wall, due to inadequate suturing of the plastic disc to the renal capsule. The chronic indwelling catheter was, therefore, successful in its most basic function: long-term access to the renal pelvis.

Intrapelvic pressure and pelviureteric motility were unchanged one week following cannula insertion (40 experiments). Long-term effects of the cannula on intrapelvic pressure and motitlity, renal function and Whitaker testing were assessed by comparing results at the time of cannula insertion and one month after the procedure. The results are shown in Table 1 and Fig. 3. No significant effect on upper tract dynamics appears to be caused by the cannula and similarly obsruction is not caused by the presence of this device. Renal function as measured by creatinine clearance was unchanged at one month following insertion. Results of intrapelvic pressure, creatinine clearance and Whitaker test in this group were reliably reproduced in control animals from other experiments.

The cannula was used in a number of additional separate experiments. Using an experimental model of partial ureteric obstruction, the cannula enabled serial measurements of intrapelvic pressure and motility (Fig. 4) and these results are reported elsewhere [5]. The cannula has also been used to perform Whitaker tests on experimentally obstructed canine upper urinary tracts and the reliability of this test for prediction of the presence and degree of experimental partial ureteric obstruction has been established [6] (Fig. 5). During the Whitaker test measurements, the bladder is continually drained via a catheter and intravesical pressure is continuously monitored. The indwelling cannula was further used to perform nephrostograms by injecting radio-opaque contrast into the upper tract via the percutaneous needle (Fig. 6). This has provided anatomical (configuration of the upper tract) and physiological data (active transport in the upper

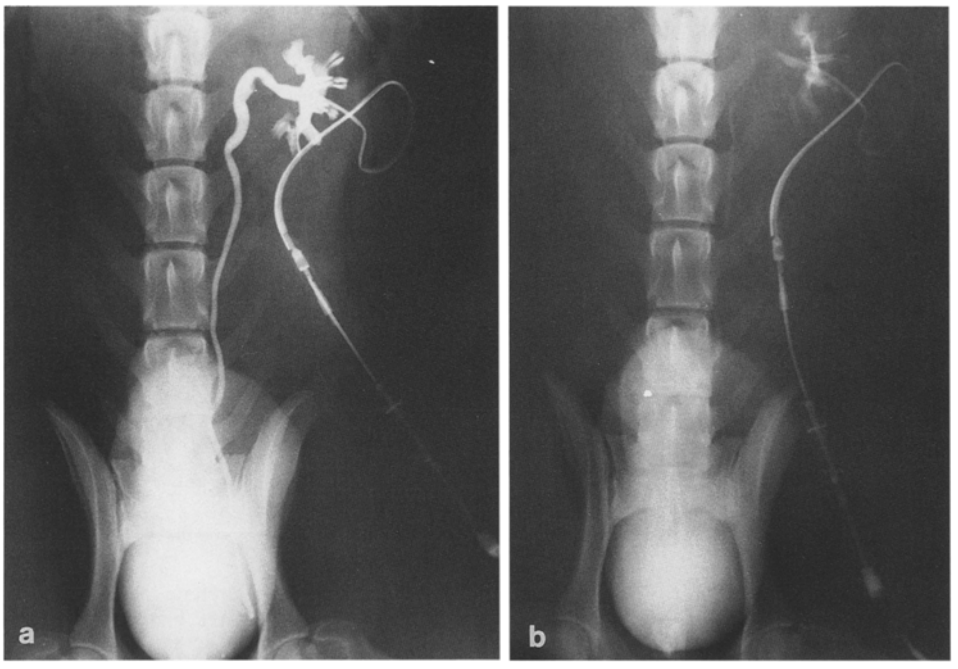

Fig. 6a and b. Nephrostography. Radio-opaque contrast has been injected into the indwelling cannula via a needle passed percutaneously into the Heplock. Note that the Heplock lies near the vertebrae on the animals back. **a** Renal pelvis, ureter and bladder are demonstrated (the upper ureter has been dilated in this experiment). **b** After 90 seconds, the upper tract has emptied itself of contrast, indicating that active peristalsis and transport is intact

tract) in experiments concerning ureteric dilatation. Finally, the indwelling cannula has been more recently employed to provide nephrostomy drainage of severely obstructed upper urinary tracts. This is achieved by suturing the 18G needle to the skin on the animal's back allowing continuous drainage of urine from the obstructed upper tract.

Discussion

Experimental techniques should be easy to perform, cheap, and both reliable and reproducible. There must be minimal invasion and complications, and, where measurement techniques are concerned, the technique must not, of itself, interfere with the parameter being measured. Insertion of the chronic indwelling catheter as described in this paper can be performed by a single operator in under 30 min. The materials are in everyday clinical use and, therefore, cheap and easy to obtain. The technique has been found to be a reliable method of gaining long-term access to the renal pelvis. Complications are uncommon and access to a remote anatomical location is provided on a long-term basis with minimal invasion. Studies on the effects of the indwelling cannula alone indicate that there is no significant effect on renal function or upper tract motility. These results are in agreement with data from a recent study [11].

This technique is similar to that described by Schweitzer et al. [7] in that a transcortical cannula is used with the luer end subcutaneously placed. There are a number of modifications. The operation is performed via a small subcostal loin incision, rather than a long midline. Minimal dissection and disturbance of intra-abdominal contents was thus ensured. This may account for the lack of abdominal complications in the present study. Renal anatomical position and attachments were also unaltered. Insertion of the dilators was found to be an accurate and reliable way of entering the small canine pelvis, and the plastic disc is fixed to the kidney only after insertion and placement of the cannula. Tunnelling of the cannula and Heplock to lie close to the vertebral spinous processes means that the animal could not reach either the suture site or a drainage needle left in place post-operatively. Finally, regarding materials, the 3 components of this system are easily obtained. The cannula, in our experience, was stable at body temperature, the plastic disc inert and the Heplock a ready-made subcutaneous needle insertion site.

Recently, a technique similar to that described by Schweitzer et al. has been published in which a midline incision with transperitoneal renal mobilization is used to insert nephrostomy tubes [11]. The technique described entails an incision in the renal "pelvis" to insert a guidewire for transparenchymal passage. Since the canine pelvis in intra-renal, this incision may well be in the proximal ureter and either ureteric injury or variable tube placement may explain unreliable Whitaker test results found in that study. However, it was shown in the study that the presence of nephrostomy tubes for up to 24 months did not cause altered renal function or renal tract calcification.

This study has demonstrated a range of useful applications for the intrapelvic cannula: pressure and motility measurement, Whitaker testing, nephrostography, measurement of creatinine clearance and nephrostomy drainage. It is also likely to be a useful method of obtaining pelvic urine samples. This technique appears to be a means of access to the renal pelvis that is preferable to retrograde passage of a catheter up the ureter, the latter procedure having been used to monitor pressure and motility [2, 4, 8, 10], measure Whitaker test [1] and perform contrast pyelography. [3].

The chronic indwelling cannula has proven to be a simple, cheap method of gaining reliable canine intrapelvic access. Complications are negligable and no significant effect on renoureteric physiology was demonstrated. This technique has many uses and applications in experimental renal and ureteric pathophysiological research.

Acknowledgements. We would like to thank the Irish Stone Foundation for funding this research, and Ms. Phillipa Marks for her technical assistance.

References

1. Boyarsky S, Martinez J (1965) Pathophysiology of the ureter: partial ligation of the ureter in dogs. Invest Urol 2:173
2. De Luca FG, Swenson D, Smyth B (1961) The effect of chronic mechanical obstruction on ureteral peristalsis. J Urol 85:497
3. Govan DE (1961) Experimental hydronephrosis. J Urol 85:432
4. Rose JG, Gillenwater JY, Attinger F, Sim P, Wyker AT (1973) Ureteral wall tension: a new means of evaluating ureteral function. Invest Urol 10:480
5. Ryan PC, Fitzpatrick JM (1987) Partial ureteric obstruction: a new variable canine experimental model. J Urol 137:1034
6. Ryan PC, Maher K, Hurley GD, Fitzpatrick JM (1989) The Whitaker test: experimental analysis in a canine model of partial ureteric obstruction. J Urol 141:387
7. Schweitzer FAW, Bowden NLR, Boyd EGCA (1972) A new method for long term monitoring of intrapelvic pressure in the experimental dog. Invest Urol 10:5
8. Stodin JG, Holmlund DEW (1982) Effect of saline lead, roentgen contrast medium and indomethacin on diuresis and pelvic pressure in the acute obstructed kidney. Br J Urol 154:466
9. Struthers NW (1969) The role of manometry in the investigation of pelvi-ureteral function. Br J Urol 41:129
10. Vaughan ED, Sorenson EJ, Gillenwater JY (1970) The renal haemodynamic response to chronic unilateral complete ureteral occlusion. Invest Urol 8:78
11. Vela-Navarrete R (1988) Tolerance to bilateral subcutaneous nephrostomy in dogs. J Urol 140:194

Prof. John M. Fitzpatrick, Mch, FRCSI
Surgical Professorial Unit
Mates Misericordiae Hospital
47 Eccles Street
Dublin 7
Ireland