

## AN EXPERIMENTAL STUDY OF URETERAL LIGATION; DEMONSTRATION OF LATE RESULTS TO URETER AND KIDNEY<sup>1</sup>

By JOHN R. CAULK, A.M., M.D., AND R. F. FISCHER, M.D., St. LOUIS

A PRELIMINARY report on ureteral ligation was given before this Association in 1915, the basis of the report being the discussion of a patient on whom both ureters had been ligated during a hysterectomy for fibroids, and who had passed no urine for eight days. It was recognized early that the ureters had been tied, but the surgeon awaited developments, thinking that possibly the catgut would loosen and the ureter would open spontaneously. At the end of the eighth day the patient became uræmic. At this time I saw her and advised double nephrostomy, which was acceded to and done with very little disturbance to the patient and with the result that during the next twelve hours over 100 ounces of urine were secreted, the analysis of which showed a specific gravity of 1007, a trace of albumin and the sediment to contain granular and hyaline casts and red blood cells. Drainage through the nephrostomy tubes was free until the fifty-eighth day, when the patient voided. Ten days later the urine was passed entirely by the bladder and the wound had healed.

At this time the patient's condition was good, but the kidney function as determined with phthalein was quite low. Since then I have watched this patient with great interest.

She is in excellent health, and her renal function has returned to normal limits. This observation clearly demonstrates that kidneys which have been completely obstructed for 8 days are capable of promptly resuming their function after drainage. This has been experimentally shown in the recent works of Keith and Pulford, and of Johnson. Furthermore, it establishes conclusively the fact that ureters which have been ligated with absorbable material may eventually open and drain sufficiently to allow closure of the nephrostomy wound, with the resulting complete restoration of health to the individual and without evidences of late ureteral obstruction.

Besides this case we have seen a number of instances of this complication of pelvic surgery; one other double, and several single involvements. We believe that this complication occurs more frequently than is supposed. Barney has collected 62 cases of occlusion during pelvic operations. Of these, 46 were unilateral and 16 bilateral. Kelly and Burnam state that ligation is the most frequent complication of the ureter during pelvic surgery. In this paper we will confine ourselves strictly to ligations and wish it to be clearly understood that ureteral severance is

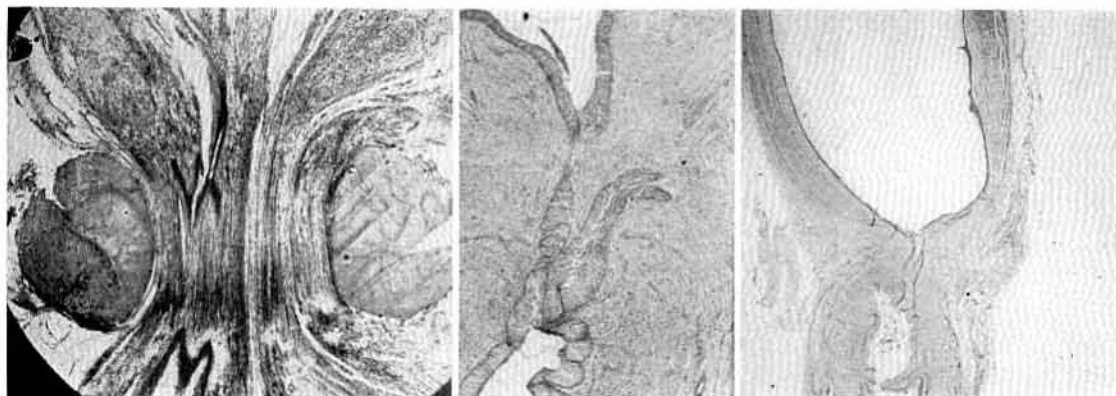


Fig. 1. Ureter at site of ligation. One hour.

Fig. 2. Five weeks.

Fig. 3. Six weeks.

<sup>1</sup>Read before the American Association of Genito-Urinary Surgeons, June 16, 1919.

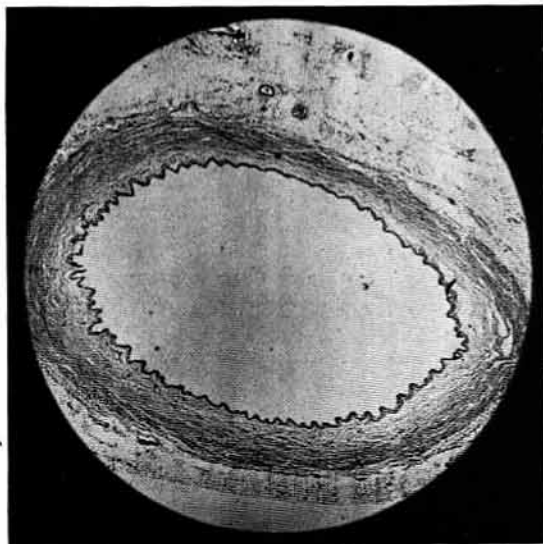


Fig. 4. Ureter above ligation.

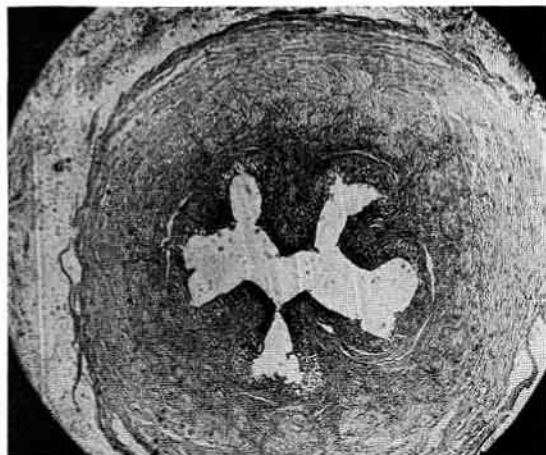


Fig. 5. Ureter below ligation.

not under consideration. The bilateral cases, of course, manifest themselves by anuria, and demand urgent relief, whereas a unilateral ligation, owing to either complete absence or a great paucity of symptoms may not attract the surgeon's attention to the possibility of renal occlusion.

The clinical cases which we have observed stimulated us to undertake an experimental investigation of this important point. Our preliminary report dealt only with the immediate effects of such ligations and bore chiefly on the subject of double ligation in which urgent measures are indicated in order to save the life of the individual. We wish now briefly to summarize our previous findings and to append our observation on the late results.

Experiments were done entirely on dogs, and in all 70 animals were used. The pathological specimens have been demonstrated to the American Urological Association at its meeting in St. Louis and to the Society of Clinical Surgeons. At present we will not give a detailed protocol of all the experiments, but for the sake of brevity will summarize our findings. The problem before us appeared to be as follows:

In case of double ligation, is it better to deligate the ureter, to do a ureterovesical

anastomosis, or a double nephrostomy in the hope that the ureters will finally open and the kidneys be saved? Inasmuch as the idea seems current that catgut, the ligature usually employed, will be absorbed sufficiently within a few days to allow the ureter to open, we endeavored first to determine the time necessary for the absorption of No. 2 plain catgut (Fig. 1); second, if the ureter after such ligation would finally open, and the manner in which this opening occurred; third, the length of time required for it to open; and lastly, the renal complications at various intervals following sudden occlusion of the ureter.

Our experiments consistently showed that No. 2 plain catgut was never absorbed before the end of three weeks. In other words, it would be futile to wait for the catgut to be absorbed before attempting to save the kidney.

Granting that the catgut would not be absorbed before the death of the individual in the case of double, or before almost complete, destruction of the kidney in the case of single ligation, one of the three procedures just suggested, namely, deligation, ureterovesical anastomosis, or nephrostomy, must be adopted. The ideal method, of course, would be immediate deligation, but such an operation would seem to be attended with considerable difficulty, inasmuch as searching for a tie on a ureter deep in the

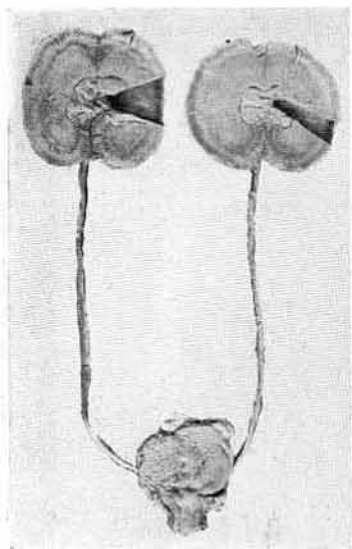


Fig. 6.

Fig. 6. Deligated right ureter at end of 1 year.

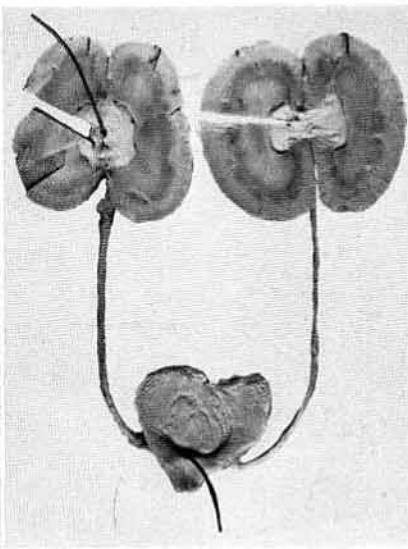


Fig. 7.

Fig. 7. Right kidney and ureter at end of 1 year. Nephrostomy fourth day; tie left on ureter. Notice open ureter.

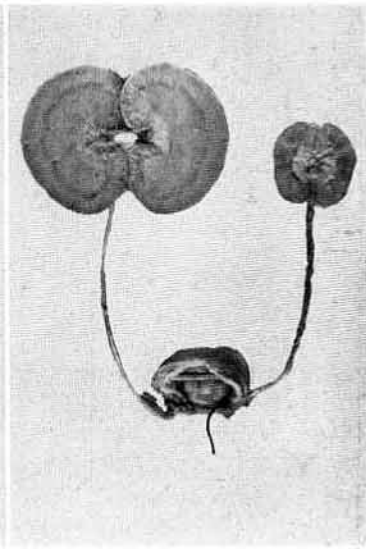


Fig. 8.

Fig. 8. Kidney atrophied at end of 1 year. No nephrostomy; ureter open.

pelvic cavity several days after an extensive resection, is a problem attended with considerable difficulty. Even in animals we have had trouble in removing the ligature, owing to its being buried within the ureteral wall, and in a fair proportion of the experiments our attempts to deligate without cutting the ureter, in spite of our strictest attention, were unsuccessful. In several instances in which I have known of its being done clinically, the ureter has been incised with a resulting fistula, or a ureterovesical anastomosis performed at the time.

Such anastomoses at best are not entirely satisfactory and are frequently attended with contraction and obstruction, and certainly are difficult under the circumstances. Furthermore, the danger of hæmorrhage must be considered since the ligature which implicates the ureter also includes within it the uterine vessel.

Faced with these difficulties and occasional dangers, we undertook the problem above described and found, as some of you will remember, that the first indication of the formation of a lumen through the site of ligation occurred at the fifth week (Fig. 2). There was at this time a budding out of

epithelium both from above and below, growing toward each other, and a definite column of epithelial cells joining them. We also noticed a beginning lumen which seemed to funnel from above. At the end of six weeks the canal had found its way through the connective tissue and had opened sufficiently to allow fluids to be injected through (Fig. 3). We will not describe in detail the preparation of specimens or the pathological change in the ureteral wall above and below the ligature, as they were given completely in the previous report.<sup>1</sup>

At the end of 8 weeks the ureteral lumen is fairly well opened and while the gross specimen

<sup>1</sup>Tr. Am. Ass. Genito-Urin. Surg., 1915.

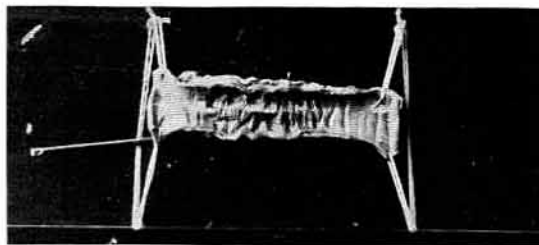


Fig. 9. Section of ureter at 7 months. Notice open lumen at site below.

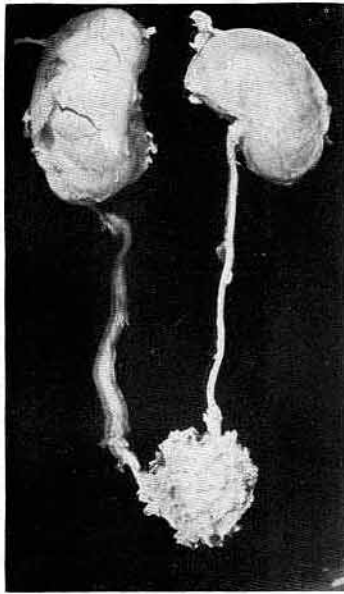


Fig. 10.

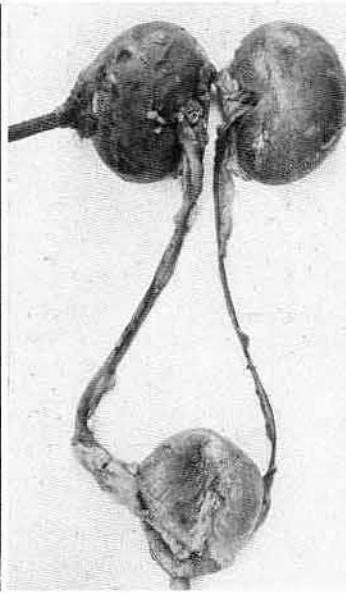


Fig. 11.

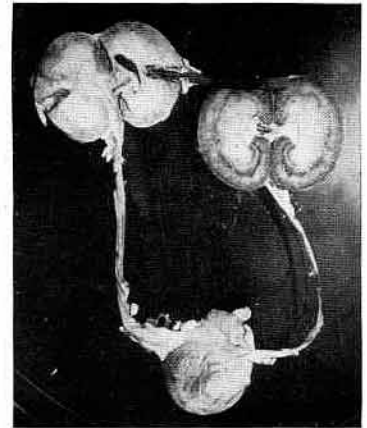


Fig. 12.

Fig. 10. Right ureter ligated 1 week.

Fig. 11. Right ureter ligated 1 week, but kidney drained third day.

Fig. 12. Same as Fig. 11. Section.

seems to demonstrate that the site of ligation is considerably restricted, it is universally found that this is more apparent than real, as far as the lumen of the ureter is concerned, since the proportionate size between the lumen of the lower ureter and of the compressed ureter is not as much at variance as the ureteral wall would indicate. At 12 weeks the lumen is more open and there is much less pronounced constriction. The wall of the ureter in this segment is thinner and composed of delicate connective tissue, etc.

We have several animals which have gone a year following the ligation. Those which were nephrotomized and in which we were successful in keeping the drainage tube in the kidney in place for several weeks, have remained healthy and well; the kidney sinus has subsequently closed and at autopsy at the end of this time, the kidney on the side corresponding to the ligation has been remarkably well preserved, in striking contrast to the kidney which was not drained behind the obstruction. (In such a case there is, of course, complete atrophy. Figs. 6, 7, 8.) The lumen of the ureter is open and free (Fig. 9), and a No. 6 catheter passes easily,

but the ureter itself is shorter and thicker than a normal one.

The ultimate opening of a ureter following a protracted ligation serves as a demonstration of the amount of damage a ureter will tolerate without the production of a pronounced stricture. It also confirms my strong belief that ureteral strictures are not as frequent as one is led to believe; that the majority of them are spasms in the neighborhood of inflammatory processes. This can be beautifully demonstrated, clinically, by the administration of repeated doses of atropine to patients who seem to have a ureteral stricture, whereas they can frequently be easily catheterized with a large catheter after atropine, notwithstanding their previous impermeability.

*Effects upon the kidney.* We shall not consume time in giving the detailed findings of the kidney complications secondary to complete ligation of the ureter as they were thoroughly described in the previous paper, and have been fully studied by Lindemann, Sollmann, Williams, Legueu, Cohnheim, Pierce, and beautifully illustrated by the splendid work of Barney, which was presented before this association; more recently by

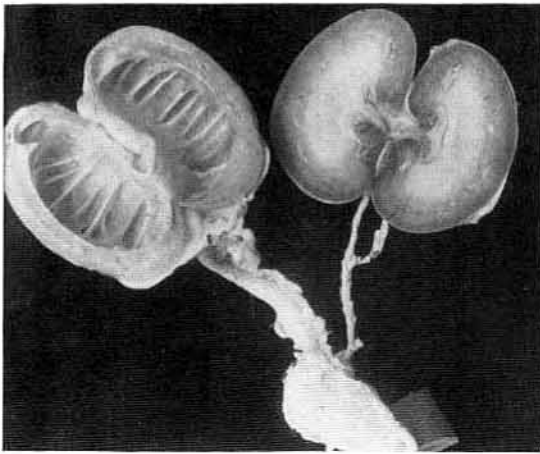


Fig. 13. Ureter ligated two weeks. Marked hydro-nephrosis.

Reid, by Keith and Pulford, and by Johnson. I wish to refresh your memories, however, by showing illustrations of the various degrees of renal involvement at different intervals following the obstruction (Figs. 10 to 15), in order to demonstrate how essential it is that prompt attention be paid to the ligation if there is to be hope of saving the kidney. It should be noted that dilatation of the ureter and kidney pelvis start fairly promptly after the ligation. Reid's work seems to show that the first dilatation is just above the site of ligation. We have not in our experiments seen it confined so definitely to the lower part, but have found it to be general throughout the ureter and kidney pelvis. As you can see from the sections, there are various grades of hydro-nephrosis up to the fourth or fifth week, at which time the kidney is seriously damaged, and often nothing of the cortex left but a shell (Figs. 14 and 15).

The ureter in all of these ligations has been tortuous, which explains why ureteral catheterization may be impossible even though the ureter has opened. Thus it seems evident that if one hopes to conserve the kidney the obstruction must be relieved, certainly within two weeks, as after that it may be irreparable. This has recently been demonstrated by Johnson who has shown that the functional test may return to normal in an animal whose kidney has been obstructed for no

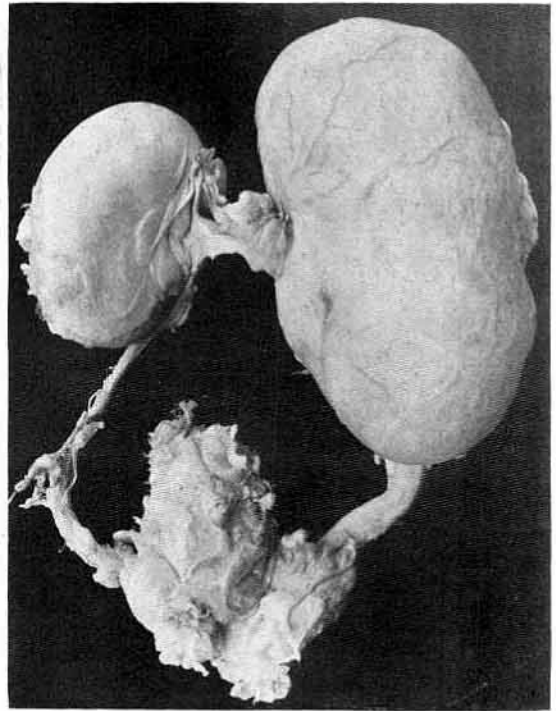


Fig. 14. Ureter ligated 4 weeks.

longer than two weeks. The longer the period of obstruction the slower the rate of recovery.

In a series of experiments which have been done to determine the nitrogen content of the blood following single ligation of the ureter, we have found that in some of these animals there is a gradual rise of the blood nitrogen content until the time the kidney is drained — which was usually the fourth day. Following this, there is a sudden rise, in some instances, but usually a very slight one. Then within 2 to 4 days after drainage the blood nitrogen drops to normal and remains so if the drainage is sufficient.

This restoration of function after a prolonged obstruction has an important clinical significance, and demonstrates to us how careful one should be in suggesting nephrectomy to patients whose kidney function may be extremely low in the face of retention. We should always try to relieve the retention conscientiously before attempting to sacrifice a kidney, as so frequently kidneys which

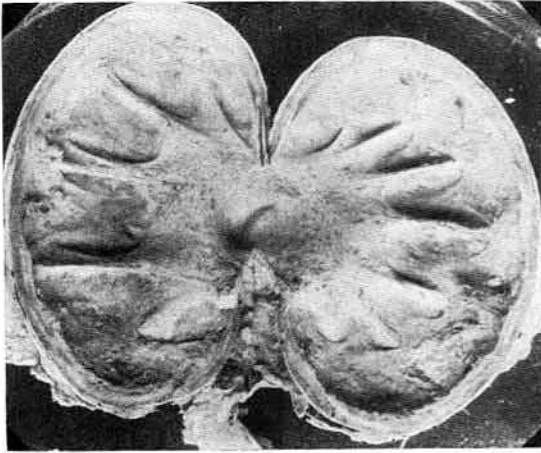


Fig. 15. Same as Fig. 14.

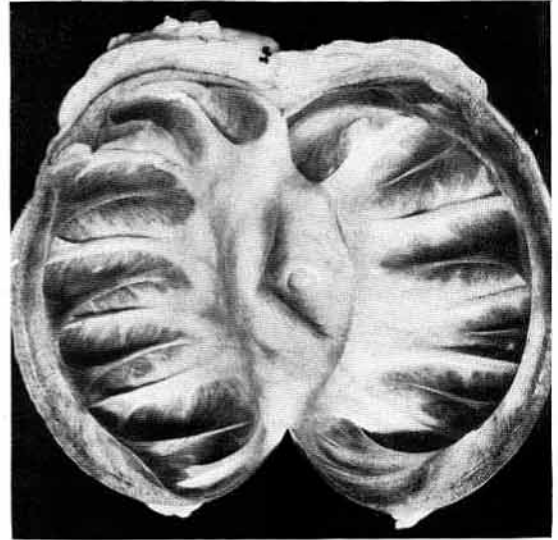


Fig. 16. Kidney at end of 6 weeks.

seem functionally hopeless have been restored after retention is relieved. Therefore, clinically, we must relieve a kidney of complete retention before the end of 2 weeks.

In double ligation, of course, one should drain promptly after the ligation is appreciated in order to save the life of the individual. In single ligation, however, the problem presents a different aspect. In this instance the life of the kidney alone is to be considered. Shall we allow the kidney to die unmolested, or shall we exert every effort to protect it? The difficulties in this phase of the question are manifold. In the first place since the symptoms may be insignificant, many ligations may pass entirely unappreciated both by patient and surgeon. If they are recognized and appreciated, the surgeon is confronted with these questions: Shall he propose to his patient that there is a surgical complication which she may never become aware of, and which may probably disturb her health but little if at all, if left unrelieved; or shall he suggest another operation which though attended with some risk and more suffering, will in all probability give her much greater renal capacity? Again, is there danger that another operation, several days after pelvic surgery, would be too hazardous? Are the results that we can offer commensurate with the danger and difficulties of the problem; and which phase of the problem presents itself as the most

suitable avenue of approach for the ultimate relief of renal embarrassment and restoration of health?

We shall attempt to answer these questions in our summary. We feel entirely convinced that catgut will not be absorbed rapidly enough to protect a kidney against complete destruction, so that in double ligation a prompt response is necessary after the appreciation of a ligation. Our experiments and clinical observations seem to indicate that a ureter which has been ligated with catgut will eventually open sufficiently to allow complete drainage from the kidney, and that this opening takes from 6 to 8 weeks or more, during which time a kidney will be completely destroyed unless protected by drainage, either through the kidney or through the ureter.

Faced with the difficulties of deligating a ureter, such as reopening an abdominal wound and searching for a small tie in a pelvis imbedded with plastic exudate, and the ureter incorporated with the uterine vessels, with the consequent danger of hæmorrhage and the possibility of cutting the ureter with a resulting fistula — certainly a much more serious operation than a double nephrostomy — and with the same difficulty attending a ureterovesical anastomosis (with

the exception of hæmorrhage), we are of the firm belief that the safest method of protecting the individual is an immediate double or single nephrostomy.

We are impressed that dealing with single ligation, such as we propose, may not have as large a field of usefulness as it merits. In the first place, the diagnosis of single ligation may prove difficult, as the symptoms may be slight. If, however, a woman who has undergone pelvic operation complains of pain in the kidney, which is usually about the third day, and this kidney is found to be enlarged and palpable, not having been so beforehand, such symptoms are highly suggestive of ureteral ligation. If the patient's condition would warrant it, a ureterogram would clinch the diagnosis. It is then for the surgeon to decide whether it is better for the patient to allow the kidney to die or to try to protect it. It seems certain that no reputable surgeon would be embarrassed in

making this situation known, provided there is a fair chance of saving the kidney. The danger of a unilateral nephrostomy should be extremely slight, as it can be done under local anæsthesia and certainly quickly under gas.

With such a fair chance of the ureter opening and the kidney healing in good condition, we believe that this should be the procedure. Granting that it may not be successful, even then the patient's ultimate condition is as good as it would have been had the attempt not been made, and we would have fulfilled our chief urological duty, namely an attempt to conserve the renal parenchyma.

#### REFERENCES

- BARNEY. *Tr. Am. Urol. Ass.*, 1904.  
KEITH and PULFORD. *Arch. of Int. Med.*, 1918, xx.  
REID. *Bull. Johns Hopkins Hosp.*, 1918.  
JOHNSON, R. J. *Exp. Med.*, 1918, xxviii.