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Renal Arterial Calibre after Acute Unilateral Ureteric Occlusion

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The immediate effect on renal blood flow following ureteral occlusion may have some relative pertinence in clinical considerations of excretory urography in cases of acute ureteral obstruction where varying appearance times of obstructive nephrograms and pyelograms are observed. Some variance of physiological observation of the changes in renal blood flow has been observed and because of this possible radiological interest a radiological approach to the problem was attempted.

Selkurt (1963), using P.A.H. clearance studies, suggested there was increase in renal blood flow immediately following ureteral occlusion.

Finkel *et al.* (1968), using radioisotopic methods with ^{85}Kr and with considerable ureteral occlusion pressure greater than 90 mm. of Hg, suggested that such increase was regional, localized more to the cortex, and was shortly followed after an interval of one hour occlusion time by some reduction in medullary flow. However, an overall increase remained for a two-hour period.

Wax (1968), measuring with ^{131}I Hippuran, showed that effects on the renal blood flow varied with the amount of ureteral occlusion pressure. At lower pressures, up to 75 mm. of Hg, the R.B.F. was elevated, but at 90 mm. decrease was demonstrated by these radioisotopic studies.

Murphy and Scott (1966), using electromagnetic flowmeters, showed an increase in renal blood flow with an average ureteral occlusion pressure of 67 mm. of Hg.

Vaughan *et al.* (1968) showed an initial rise with flowmeter methods up to five hours, with subsequent reduction after this period of obstruction.

The well-established arterial calibre reduction following unilateral occlusion has been well documented by Widen using dogs and Idbohrn in rabbits. They show the gradual constriction of the artery, the calibre of the renal artery decreasing with increasing duration of ligation. Their studies commenced no earlier than four days (Widen, 1958) or seven days (Idbohrn, 1966). The alteration in calibre at earlier periods, as judged by radiographic measurements, has not been subject to detailed study.

Herdmann and Jaco (1950) found a distinct reduction within 24 hours, but made no exact measurements in their cineradiographic studies.

Elkin *et al.* (1964) failed to show any marked alteration in arterial calibre but noted venous dilatation after acute ureteral occlusion states. Although arteriography cannot accurately indicate blood flow, it does offer a method of studying changes in the main renal artery without any major physiological disturbance, and with this method the changes in calibre in the first few hours after occlusion were subject to close study.

MATERIAL AND METHODS

Anaesthetized dogs were used and an initial aortogram was performed with the catheter placed just above the renal arteries. When the catheter was accurately placed a bolus of between 8 cc. and 10 cc. of methylglucamine and sodium diatrizoate (either Urografin 76% or Renografin 76%*) was injected.

Extreme care in having identical position of catheter, X-ray exposure factors, and the same amount of identical contrast at all aortographic examinations in the same animal were observed. At a variable time after initial aortographic study a unilateral ureteral occlusion was performed through an extraperitoneal loin incision. Complete ligation was ensured by transsection of the ureter and triple ligation. The site of ligation was made as low as possible, in most cases below the pelvic brim. Subsequent to the ligation, aortographic studies were made at different time intervals in different animals. In a number of dogs ureteral pressure measurements were made at the end of such ligation periods with a multiple side-holed polyethylene catheter with the open end occluded. This was measured after satisfactory angiographic studies had been obtained.

RESULTS

There were 26 determinations from 25 animals of the changes on the ipsilateral side. In one dog, examination at 20 minutes was followed by further examination at 19 hours. All calibre variations were measured as a percentage of the

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* Urografin 76%, Schering; Renografin 76%, Squibb.

original by measurement on three separate occasions of the diameter of the renal artery at about 0·5 cm. from its origin and at a point 0·5 cm. proximal to its first bifurcation.

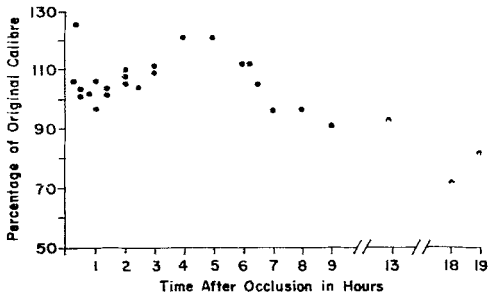

FIGURE 1.—Details the percentage calibre variations on ipsilateral side.

Averages were made from these six measurements. Such measurements were made with a scale incorporated within a magnifying lens (×7). The accuracy of measurement was considered to be better than 0·1 mm. The percentage calibre variations on the ipsilateral side are recorded in Figure 1 and show an initial rise in the early period up to seven hours, following which the well-known marked reduction in calibre was demonstrated. There were 19 determinations in 19 animals on the contralateral side, and these are shown in Figure 2. The extent of calibre increase on this side is not as marked, but the continued rise in studies at later intervals was noted. No contralateral measurements at intervals later than eight hours were detailed.

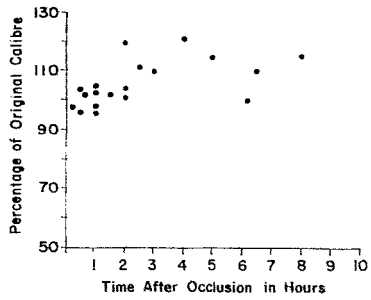

FIGURE 2.—Details the percentage calibre variations on contralateral side.

Ureteral pressure measurements were confined to the early period and consisted of five examinations only within the first 90 minutes after occlusion. The range of measurement was 10 mm. to 25 mm. Hg and the figures are given in Table 1.

DISCUSSION

The increase in calibre seen on the contralateral side averaged less than 2% in the first two hours, whereas the ipsilateral measurements showed an average 8% rise in arterial diameter. Consideration of Poiseuille's equation would allow an 8% increase in diameter to correlate with a 30% increase in flow, which would approximate to the increase shown by other authors (Finkel *et al.*, 1968; Wax, 1968; Murphy and Scott, 1966; Vaughan *et al.*, 1968) within the first hour. Many criticisms (Price *et al.*, 1964; Byar *et al.*, 1965) of Poiseuille's law in the assessment of flow in cases of localized segmental narrowing in peripheral vessels have been made. McDonald (1960) indicates that Poiseuille's law applies to conditions of flow at a constant rate and in some vessels, including the renal artery, other variations of blood flow, such as turbulent flow and oscillatory flow, have such little influence that calibre variations may possibly denote gross changes in blood flow.

TABLE I

Dog	Minutes After Occlusion	Pressure (mm. Hg)
1	20	22
2	30	15
3	40	25
4	60	10
5	90	20

In clinical states Delin *et al.* (1966), using electromagnetic flowmeter estimations, found arteriography of renal stenotic lesions very satisfactory in estimating flow changes. Also Ludin *et al.* (1967) have correlated quite accurately renal artery calibre and effective renal plasma flow in 42 patients. Whether aortography and measurement of calibre will allow assessment of the amount of flow in experimental situations is very debatable, as the influence of peripheral resistance, especially under general anaesthesia, may be considerable.

The increase in calibre shown in the first few hours may be primary or may be effected by such alterations in peripheral resistance. The pressure alterations within the renal tissue may be responsible either by the presence of metabolites, a possibility in the early minutes where a change on the contralateral side is probably equally as prominent, or occasioned by venous arteriolar reflexes.

The extent of ureteral pressure rise would appear to affect the degree and the rate at which

the R.B.F. alteration occurs. Dehydrated states and the promotion of diuresis either due to water or osmotic material will affect (Baldwin *et al.*, 1967) renal blood flow and may well account for some of the discrepancies between the physiological studies.

Autoregulation (Thurau, 1964) within the kidney certainly plays a part in maintenance of flow, but some reaction based upon ureteral or intrarenal pressure changes would appear to follow from these radiological observations. When the ureteral pressure rises sufficiently with increase of duration of occlusion, then vasoconstriction within the kidney could occur following rise in intrarenal pressure. This study would seem to suggest that such a rise in renal pressure occurs at approximately seven hours when vasoconstrictive, shunt, and other influences presumably become effective.

Influences on these alterations in renal blood flow on the density of the nephrogram and its rate of conversion into an obstructive pyelogram seem possible as the variability sometimes seen of this contrast alteration is often difficult to explain. Although, as Elkin (1963) has emphasized, the duration and the completeness of obstruction is primarily responsible for the rate of alteration and the subsequent development of the pyelographic appearance, perhaps the cycle of changes of renal blood flow that this study confirms may help to explain some of the discrepancies apparently dependent on the duration of occlusion. Elkin's clinical study, based upon the duration of obstruction as judged by symptom commencement, may well be correlative of this reversal of pattern as the number of acute pyelograms seen within 30 minutes approximates to the number of those obstructions of lesser duration than 24 hours. Elkin emphasizes the difficulty of determination of exact assessment of duration of obstruction and notes how in his animal experiments an obstructive pyelogram appeared within a few minutes.

With increasing use of acute urography in such obstructive situations (McLean *et al.*, 1969) coincident with the greater yield of diagnostic information (Smith, 1966), many more acute ureteral occlusions will be studied within the first few hours. It is often rewarding in such cases to see the early pyelographic appearance, no doubt aided by increased blood flow up to seven hours and accentuated by subsequent blood flow reduction. In acute cases of obstruction of longer duration, although pyelographic appearances do ultimately follow, the decreased blood flow will lessen the nephrographic density and, although concentration does occur, there is often a considerable delay before the site of obstruction can be adequately demonstrated.

Perhaps this explanation of difference in renal blood flow may help to explain why acute urography may well have distinct value.

CONCLUSION

Recent physiological investigations show some variance in the pattern in the renal blood flow alteration immediately following ureteral occlusion. However, with increase of duration of occlusion and consequent increased ureteral occlusion pressure, it would appear that the initial rise is reversed.

This reversal pattern has a confirmatory radiographic basis in this study of a small series of experiments at varying time intervals in the first few hours after occlusion. An increase in radiographic calibre is shown in the first seven hours following obstruction, and although doubt may be expressed as to the relation between calibre and flow these findings may be presumed to correlate with measurements obtained by other methods.

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