RENAL TRAUMA: A STUDY OF 71 CASES

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Trauma to the kidney presents a critical situation which demands prompt, active management along preconceived lines.

Until fairly recent times, the majority of surgeons, both general and specialist, have held to the belief that these cases were best treated by expectancy and supportive measures until such time as the increasing gravity of the condition constituted a direct and immediate threat to life. Powers[1] stated that "the majority of patients with renal trauma may be treated conservatively with the expectation that the injured kidney will recover sufficient function to be a useful and serviceable organ." Priestley[2] held that "extensive urologic investigation, including cystoscopy and retrograde pyelography, immediately after renal injury is usually unnecessary and often undesirable" and that "in the majority of cases, medical treatment will be followed by functional results which are satisfactory, although various types of anatomic abnormalities may persist." He noted that, of 19 patients treated medically, 26.3 per cent still had symptoms referable to previous kidney injury, although these symptoms were not incapacitating. Sargent[3] was in favor of complete urologic study, including retrograde pyelography, to determine the extent of injury but in 1945[4] stated the principle that "most kidney injuries should be left alone. If the renal pelvis is reasonably intact, the patient will soon recover. If the contour of the pelvis is blasted beyond recognition, nephrectomy is necessary." In support of the above views, it is conceded that urological experience includes many instances of slight or moderate injury to the kidney in which conservative therapy has resulted in a return to normal health.

In cases where the injury is more extensive, the policy of nonsurgical management has several major defects:

1) The period of "watchful waiting" may well extend beyond the optimal period for surgical intervention which usually occurs after the initial interval of shock has been overcome, thus prejudicing the patient's chances for survival. Cheetham[5] stated that the majority of operative deaths are due on the one hand to the severity of the primary injury, and on the other to procrastination in exploration. Swan,[6] citing 1,232 cases of renal injury treated by nonintervention, in which 264 (21.4 per cent) died, gave as his belief that "of this group many that

[1] Powers, J. H.: Surg., **3**: 397, 1938.
[2] Priestley, J. T.: Surg. Clinics of N. Amer., **19**: 1033, 1939.
[3] Sargent, J. C.: J.A.M.A., **115**: 822, 1940.
[4] Idem: J. Urol., **53**: 381, 1945.
[5] Cheetham, J. G.: Surg., Gynec. & Obst., **72**: 573, 1941.
[6] Swan, R. H. J.: Brit. J. Urol., **12**: 161, 1940.

died from hemorrhage might have been saved if timely operation had been performed."

2) Late complications, the sequelae of extravasation of blood and urine with subsequent infection, may arise. These include abscess formation,[7] hydronephrosis, pyonephrosis,[8] calcified hematomas and cyst formation,[9] pyelonephritis and secondary hypertension,[10] calculosis (Lazarus[11] who cites one case and quotes reports of Hinton, Torres, Masnata, Sabrozes and Bonnes, Kendall, Dubner, Rosen, Dozsa, Stirling and Lands, Livermore, and Volkmann—stone formation ascribed to antecedent trauma), and diminution or complete loss of renal function.

3) Unassociated renal disease,[6, 12, 13] underlying and contributing to the symptoms of kidney injury, may go unrecognized unless all diagnostic measures, including surgical exploration, are utilized.

4) Patients who are treated nonsurgically often undergo a protracted convalescence and remain "renal cripples" for weeks, months, or even years following their injuries.[8, 9, 14]

CLASSIFICATION

Hinman,[15] Ritvo and Stearns,[16] Stirling and Lands,[17] and Prather[18] have formulated classifications for renal injuries, based on clinical studies and experimental trauma in animals. While these are of value in retrospective analysis, the sum total of positive evidence gained by all diagnostic procedures, short of surgical exposure and visual examination of the kidney, is frequently too inconclusive to provide so detailed an estimate of the degree of injury. We have found a simpler, more condensed classification to be of practical value in determining the indications for nonsurgical as opposed to surgical management. In the majority of instances, a particular case will be found to fall into one of three definite categories: 1) minor injury (contusion); 2) major injury; 3) critical injury.

Minor injuries. Anatomically, such patients have suffered parenchymal damage without rupture of the capsule or extension of the defect into the pelvis or calyces. They do not usually exhibit shock unless there is more severe injury to other structures. Although hematuria may be alarming at first, it subsides to microscopic proportions within 48 to 72 hours. Pain, tenderness and splinting on the affected side may also be marked on first examination, but these symptoms, too, improve rapidly. No mass is palpable on physical examination of the kidney region (although it must be emphasized that splinting may conceal a mass of sizable proportions and that such a mass may be palpable only under general

[7] Turton, J. R. H.: Med. Press, **207**: 36, 1942.
[8] Robertson, J. P.: South. Med. J., **35**: 181, 1942.
[9] Colston, J. A. C. and Baker, W. W.: Arch. Surg., **34**: 99, 1937.
[10] Braasch, W. F. and Strom, G. W.: J. Urol., **50**: 543, 1943.
[11] Lazarus, J. A.: Urol. & Cutan. Rev., **43**: 529, 1939.
[12] Harrison, J. H.: Surg., Gynec. & Obst., **70**: 93, 1940.
[13] Jewett, H. J.: J. Urol., **43**: 664, 1940.
[14] Stearns, D. B.: Mil. Surg., **86**: 284, 1940.
[15] Hinman, Frank: Principles and Practice of Urology. Philadelphia: W. B. Saunders Co., 1936, p. 1009.
[16] Ritvo, Max and Stearns, D. B.: J.A.M.A., **109**: 1101, 1937.
[17] Stirling, W. C. and Lands, A. M.: J. Urol., **37**: 466, 1937.
[18] Prather, G. C.: J.A.M.A., **114**: 207, 1940.

or spinal anesthesia). Most important, excretory and retrograde pyelograms show that the pelvis and calyceal system are intact on the injured side; the demonstration of their integrity constitutes the greatest single criterion for placing injuries in the minor group.

Major injuries. Retrospective analysis of the group of cases which have been designated as "major" kidney injuries has shown that the anatomic lesion consists of parenchymal damage and capsular rupture with, almost invariably, extension of the disruption into the pelvis or calyces. While it is possible to achieve parenchymal damage and capsular rupture without perforation of the collecting system by means of the application of gradually increasing degrees of trauma to the exposed kidneys of experimental animals,[16] clinical experience indicates that injury severe enough to cause extensive parenchymal and capsular damage will usually result in perforation of the collecting system as well. Thus, a palpable perirenal hematoma is commonly accompanied by evidence of urinary extravasation on retrograde pyelography, the co-existence of the lesions being verified at operation by the presence of both blood and urine in the mass surrounding the injured kidney.

Patients who have suffered a major kidney injury present a diagnostic problem of marked proportions. Shock may or may not be present initially; its onset may be delayed for hours, days or even weeks following the traumatic incident.[19] Pain and splinting are usually present on the affected side, but may be obscured, at first examination, by symptoms and signs originating in trauma to other structures. Unlike minor renal injuries, however, the symptoms referable to the injured kidney tend to persist and to increase in magnitude. Hematuria is variable and may be inversely proportional to the degree of injury. A perirenal mass may be palpable only under anesthesia although it may occupy the entire renal fossa. We wish to strongly emphasize that physical examination may be entirely misleading in such cases. The use of the precise methods of diagnosis available to the urologist will do much to clarify the situation. The demonstration of extravasation on urography places the case directly in the "major" category.

Critical injuries. Extension of the disrupting lesion into the vessels of the renal pedicle constitutes the anatomic justification for placing injuries in the "critical" category. There is usually extensive pulpefaction of the renal capsule and parenchyma. The increasing mass in the exquisitely tender, splinted loin, along with early, profound shock and other evidences of massive hemorrhage, furnish sufficient clinical information to attest to the severity of the lesion. Excretory urography is of value chiefly in determining the presence and adequacy of the kidney on the uninjured side; it may yield valuable information even before shock has been thoroughly controlled. Retrograde pyelography is seldom necessary.

REPORT OF CASES

Seventy-one cases of renal injury were seen at the Brady Urological Institute from 1930 to 1948.* On the basis of the simplified classification which we have

cited previously, the following incidence in each of the three important categories has been observed:

Total number of cases... 71
Minor injuries.. 47 (66.2%)
Major injuries... 23 (32.4%)
Critical injuries... 1 (1.4%)

No mortality attributable to the renal injury has been encountered in this series.

A. Minor injuries. The right kidney was injured in 25 instances, the left in 22. Gross hematuria was observed in 29 cases, microscopic in 18. The average period of hospitalization was 8 days.

Urography: Excretory urography showed normal renal outlines and good function bilaterally in 25 (53.2 per cent) out of 47 cases. In 10 cases (21 per cent) excretory studies showed poor visualization or complete failure of excretion of the radio-opaque material; in these, retrograde studies of the injured side yielded the important information that there was no extravasation of dye, i.e., the pelvis and calyces were intact. X-ray studies were not made in 12 cases; inclusion of these in the category of minor injuries has been, of necessity, based on the absence or rapid disappearance of symptoms.

The fact that 6 cases (12.8 per cent) were found to have severe, unassociated renal disease indicates that the pathologic kidney reacts to trauma to a degree out of proportion to the extent of the injury and constitutes a strong indication for thorough urologic investigation in every case encountered. The underlying lesions discovered were: 1) papillary carcinoma of renal pelvis; 2) "hypernephroma"; 3) unilateral fused kidneys; 4) congenital polycystic disease; 5) bilateral congenital hydronephrosis; 6) unilateral congenital hydronephrosis.

B. Major injuries. For purposes of analysis, the 23 cases of major injury to the kidney may be subdivided into 3 groups.

Group 1 (9 cases, 39 per cent): Major injuries seen soon after the traumatic incident in whom surgery, not dictated by life-saving considerations, was carried out to prevent major sequelae or to preserve renal function.

The average interval of time between injury and operation was 60 hours. In 5 cases (55 per cent of group 1), the injured kidney was repaired; 4 cases (45 per cent) were nephrectomized. The average period of hospitalization (corrected in one instance for multiple injuries to other systems) was 19.1 days.

Follow-up: Of the 5 instances in which early surgical repair of the kidney was carried out, 4 (80 per cent) exhibited no significant complications or sequelae attributable either to the injury or to operation over postoperative periods ranging from 4 months to 8 years. No follow-up was obtained on the fifth case. Of the 4 nephrectomized patients, 2 have shown no sequelae, and it may reasonably be assumed that the third, in whom no follow-up was obtained, had no further trouble, since the kidney was removed. The fourth nephrectomized patient (in whom carcinoma of the ureter was present at the time of surgery) died 2 years later of carcinomatosis.

Group 2 (3 cases, 13 per cent): Major injuries seen immediately after the trau-

matic incident in which surgery, although indicated by our present criteria, was not carried out.

The average period of hospitalization was 20 days. Inclusion in the category of major injuries is based on urographic evidence of extravasation in 2 cases; in the third, a perirenal mass developed during the period of hospitalization and urographic studies, carried out 4 months later, showed hydronephrosis and distortion of the calyces.

TABLE 1. *Major injuries treated initially by nonsurgical methods*
(Group 2) Major Injuries Seen Immediately After Trauma (Follow-up) (3 cases)

CASE	SEX	AGE	NATURE OF TRAUMA	POST-TRAUMA INTERVAL	SYMPTOMS	CONDITION	LATE OPERATION
1 (W. B.)	M	55	Crushing injury	7 years	None	No subsequent studies	None
2 (W. M.)	M	10	Fall	8 years	Extravasation on retrograde studies—could not be contacted for follow-up.		
3 (A. H.)	M	23	Fall	4 months 15 years	None Occ. pain	Hydronephrosis Same (?)	None

(Group 3) Major Injuries Seen Late After Trauma (11 cases)

CASE	SEX	AGE	NATURE OF TRAUMA	POST-TRAUMA INTERVAL	SYMPTOMS	CONDITION	LATE OPERATION
4 (D. C.)	M	7	Fall	2 years	Pain	Hydronephrosis and nonfunction	Nephrectomy
5 (W. H.)	M	67	Fall	6 years	Renal colic, hematuria	Calculus and fibrolipomatous replacement	Nephrectomy
6 (F. H.)	M	9	Fall	10 weeks	None	Nonfunction	Deferred
7 (A. R.)	M	55	Boating accident, blow to side	6 years	Pain	Recurrent calculi; stricture of U-P junction	Nephrolithotomy (2) stricture dilated
8 (S. T.)	M	49	Severe blow left kidney	35 years	Pain	Calcified cyst	Partial removal of cyst
9 (L. M.)	M	27	Fall	15 years	Pain	Hydronephrosis, calculi	Nephrectomy
10 (S. S.)	M	21	Sledding accident	21 years	Pressure; numbness of left leg	Renal cyst	Partial excision and marsupilization
11 (S.)	M	42	Automobile	1 month	Severe pain, hematuria and shock	Complete rupture	Nephrectomy
12 (W. M.)	F	47	Severe blow	3 years	Hematuria, pain, urinary infection	Defect, lower pole	Refused
13 (P. S.)	M	8	Fall	2 years	None	Nonfunction	Deferred
14 (E. L.)	M	8	Fall	21 days	Pain	Renal cyst	Removal of renal cyst

Follow-up: Of the 2 patients who showed urographic evidence of extravasation, one has had no further symptoms; the second could not be contacted. The third, in whom hydronephrosis was demonstrated 4 months following injury, has had occasional pain in the region of his injured kidney during the ensuing 15 years, but it has not been incapacitating.

Group 3 (11 cases, 48 per cent): Major injuries seen late after trauma.

Patients in this group were seen from 21 days to 35 years following the initial renal trauma. In 8 of the 11 cases, late surgery was necessitated by incapacitating sequelae which can reasonably be attributed to the original trauma. In the 3

remaining cases, surgery was either refused (1 case) or deferred, due to the asymptomatic status of non-functioning kidneys.

Groups 2 and 3 are summarized in table 1.

In considering the total of 14 patients with major injury who were treated by nonsurgical methods during the immediate post-injury period, it will be noted that 12 (85.7 per cent) have developed renal disease of severe proportions on the injured side. In the remaining 2 cases, the exact functional status of the injured kidneys is not known. In the absence of symptoms, we have elected, for purposes of this report, to consider them as having healed satisfactorily, but the fact that 2 other cases, also asymptomatic, show nonfunctioning kidneys on
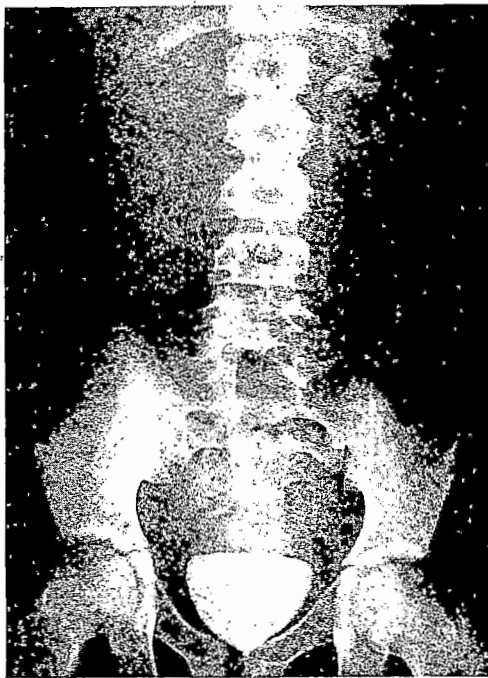

FIG. 1. Excretory urogram. Critical injury of right kidney

urography, casts some doubt on the validity of this assumption. In 8 of the 12 cases with proven severe sequelae, late surgery has been necessitated by incapacitating symptoms. In the remaining 4 cases, the necessity for surgical intervention remains a potent possibility.

C. Critical injuries. One case falls in this classification.

An 11 year old white boy (T. K.), injured in a sledding accident, was brought to the hospital in severe shock on January 29, 1948. His voided urine was grossly bloody and contained clots. A tender mass occupied the entire upper right quadrant and loin. Whole blood 2,000 cc and the utilization of other standard supportive measures were necessary before the degree of shock was lessened. An excretory urogram (fig. 1) performed while the patient was in upper shock levels, showed normal configuration and excellent function on the left side. The right kidney outline could not be defined, and there was no evidence of function on

this side; the characteristic "ground glass" appearance of a fluid-containing mass was noted in this area. After vigorous supportive therapy for 24 hours, the patient's blood pressure had risen to normal levels and the pulse rate decreased to 100 beats per minute. After what we now consider to have been an unpardonable delay of an additional 12 hours, the patient's condition showed general deterioration: falling blood pressure, rising pulse and an increase in the size of the perirenal mass. Operation, carried out 36 hours after injury, revealed a large amount of old and fresh blood in the perirenal space and extending down along the ureter. Alarming fresh hemorrhage, initiated after a portion of the hematoma had been evacuated and originating in a tear extending into the renal pedicle, was controlled by thrusting the fingers beneath the kidney and grasping the pedicle. Pedicle clamps were then applied and the severely damaged kidney removed. Convalescence was uneventful, the patient being discharged on the eleventh postoperative day.

<center>DISCUSSION</center>

We have emphasized the fact that physical and laboratory examinations are often insufficient for accurate determination of the degree of kidney injury. Moreover, it has become increasingly apparent in this study that excretory urography, while extremely valuable in demonstrating the presence of a normally functioning kidney on the opposite side, is frequently unsatisfactory in delineating the extent of injury on the affected side. Slight injury may result in complete suppression of function or in slight excretion of the radio-opaque material with disappointing lack of definition of the pelvis and calyceal structures (10 out of 35 cases of minor injury studied by excretory urography in this series); conversely, prompt concentration of the dye may occur in a kidney which has sustained considerable trauma. The latter situation is illustrated in the following case:

L. F., a 9 year old colored boy, was struck in the left side in a sledding accident 36 hours before admission on February 1, 1948. Severe initial pain in the left renal region gradually subsided during the following 24 hours, as did a bout of emesis. Hematuria was not noted. On admission, the patient was cooperative, rational and showed no evidence of marked distress. Blood pressure was 110/70; pulse 120. There was tenderness and marked muscle guarding over the entire left abdomen, flank and loin; no masses were felt. Laboratory examination showed no significant abnormality except microscopic hematuria. Excretory urography (fig. 2, A) on admission and 2 days later showed a normal right kidney. The left kidney, although its outline could not be made out satisfactorily, excreted dye promptly on each occasion. The upper major calyx was sharply defined; collections of dye in the regions of the other major calyces and the renal pelvis suggested distortion without evidence of extravasation; in other words, the findings on excretory urography were in keeping with the clinical impression of a minor kidney injury. Appetite was good, pain and tenderness had largely subsided and no further evidence of hematuria was noted on microscopic analysis; however, the patient continued to exhibit a low-grade fever. Retrograde urography was carried out on the fourth day of hospitalization. At this time, under

general anesthesia, a large perirenal mass was palpated. This finding was cor-
roborated by x-ray evidence of extravasated dye (fig. 2, B) outlining a mass
surrounding the lower pole of the left kidney. Pseudomonas aeruginosa was cul-
tured from material aspirated from the left ureter.

At operation, 5 days after admission, approximately 300 cc bloody urine sur-
rounded the left kidney, which showed a complete transverse rupture (fig. 3)
with wide separation of the upper and lower segments. The lower half, bearing
the pelvis and attached ureter, was completely ischemic except for a narrow
margin having an attachment through a small shred of capsule to the renal
pedicle. The upper half, attached to a normally pulsating pedicle, showed only
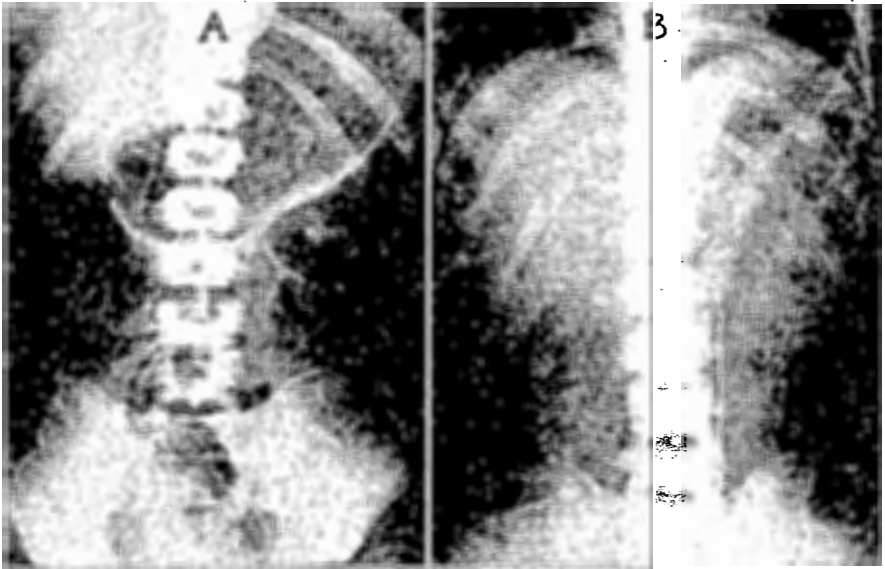a marginal area of ischemia in its lower portion. Nephrectomy was carried out.

FIG. 2. A, excretory urogram. Prompt excretion of diodrast by injured left kidney. B,
retrograde pyelogram; extensive extravasation of radio-opaque material surrounding lower
pole of left kidney.

Convalescence was uneventful, and the patient was discharged on the sixteenth
day of hospitalization.

Comment: The apparent integrity of this kidney, based on the prompt appear-
ance and sharp delineation of dye excreted by the upper half of a completely
transected kidney, resulted in a false sense of security and subjected the patient
needlessly to the dangers of infection and secondary hemorrhage. Physical and
laboratory examinations sustained the illusion of minor injury. Earlier retrograde
investigation would have clearly indicated the need for surgical intervention
and, while it is probable that the kidney would have been removed in any case,
the period of hospitalization would have been materially shortened.

In contrast with the preceding case, the following instance may be briefly
cited: R. H., a 13 year old colored boy, was admitted February 7, 1948, 4 hours
after sustaining an injury to the left loin in a sledding accident. There was no

evidence of shock. No mass could be palpated in the tender, splinted left loin. Hematuria was microscopic. Excretory urographic studies were inconclusive. Retrograde pyelography, 17 hours after admission, showed extravasation of dye from the left upper calyx. At operation, 40 hours after injury, 250 cc liquid and clotted blood were removed from the perirenal space. The upper $\frac{1}{6}$ of the kidney had been sheared off tranversely from the rest of that organ (fig. 4) and lay entirely free and without blood supply in the upper portion of the renal fossa. After removal of the separated fragment, the upper calyx was closed and the parenchymal defect repaired without nephrostomy drainage. Convalescence was complicated only by mild pyrexia; the patient was discharged on the 11th day
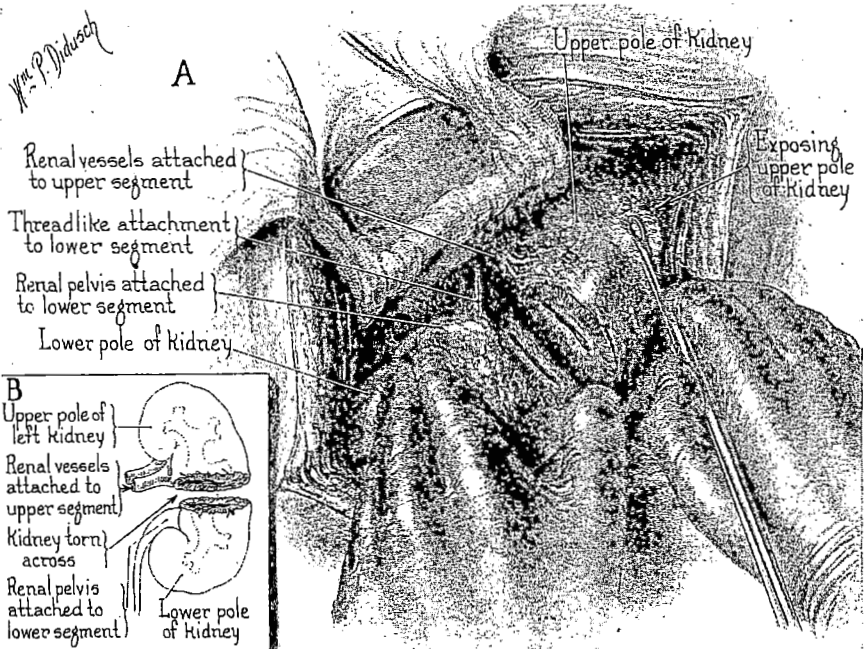

FIG. 3. Appearance at operation. Complete transverse rupture through midportion of left kidney.

of hospitalization. Follow-up 4 months later revealed good function without distortion in the repaired portion (approximately $\frac{5}{6}$ of the previously injured kidney).

Comment: Physical and laboratory examinations and excretory urography failed to accurately assess the major nature of the renal injury in this case. Early retrograde pyelography indicated the severity of the lesion and afforded a definite basis for proper therapy, i.e., operative intervention.

In all such cases in which the results of clinical investigation and excretory urography are indeterminate, we believe that prompt utilization of retrograde studies is imperative for intelligent management of the injury. Concern has been expressed in the past over the possibility of introducing infection and irritating foreign material into the perirenal tissues by this procedure. If aseptic cystoscopic

technique is used, the risk of infection is minimal and is further reduced by the concomitant administration of antibiotic and chemotherapeutic agents. Since, moreover, the evidence of extravasation, in our opinion, constitutes a positive indication for surgical exploration, the presence of the foreign material will be only transient; the fear of complications arising from this procedure is far outweighed by the diagnostic value of the information that it affords.

Renal injuries of the type which have been defined as "major" do not, in themselves, constitute an immediate threat to life. The extravasation of blood and urine is limited by the tamponading confines of the perirenal fascia; an equilibrium is usually reached beyond which further extravasation occurs very
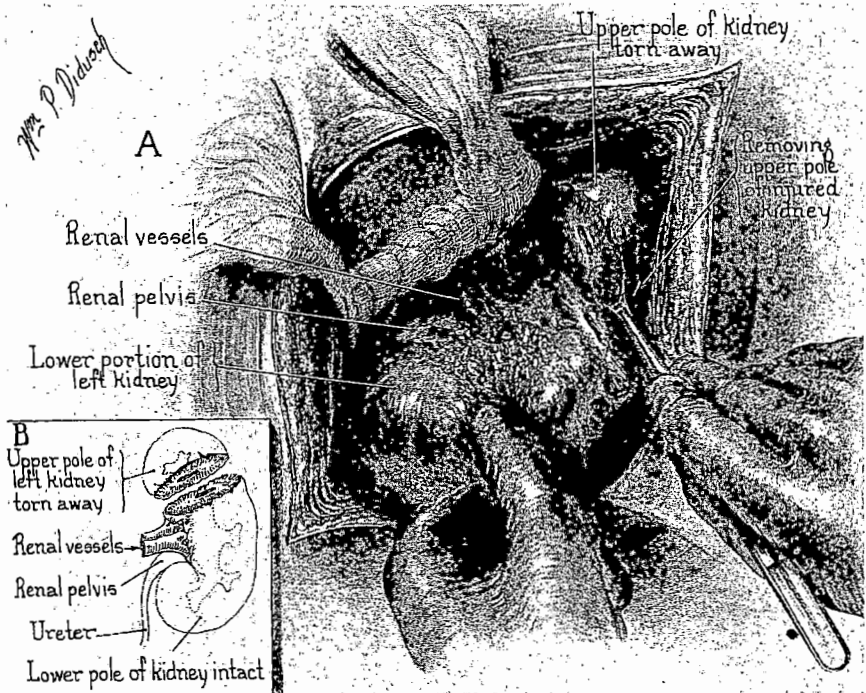

FIG. 4. Appearance at operation. Complete transverse rupture through upper pole of left kidney.

slowly or not at all. It has been the feeling of many competent and experienced urologists, conditioned by their reluctance to hazard definition of the extent of the injury by retrograde pyelography, that such cases were best handled by expectancy until such time as the hand of the surgeon was forced by unfavorable developments. However, the accumulating evidence as to the high incidence and crippling effects of late complications, coupled with the increasing desire to conserve renal tissue whenever possible, has given weight to the belief,[7, 12, 19, 20, 21, 22, 23, 24] which the authors share, that early surgery is highly indicated.

[19] Wood, A. H.: J. Urol., **37**: 437, 1937.
[20] Farman, F.: J.A.M.A., **114**: 210, 1940.
[21] Lowsley, O. S. and Menning, J. H.: J. Urol., **45**: 253, 1941.
[22] Campbell, M. F.: S. Clin. of N. Amer., **21**: 443, 1941.
[23] Kindall, L. E.: Calif. & West. Med., **49**: 115, 1938.
[24] Kimbrough, J. O. and Furst, J. N.: J. Urol., **59**: 807, 1948.

After the initial shock, if present, has been overcome by supportive measures, a period of 48 to 72 hours usually ensues during which diagnostic and surgical procedures can be carried out without the mitigating influences of infection, secondary hemorrhage and general deterioration in the patient's condition. Proper surgical drainage, repair of parenchymal and collecting system lacerations, removal of devitalized tissue, and, if indicated, nephrectomy, are measures which, if carried out during this favorable period, find their justification in shortened convalescence and prevention of immediate and late complications.

Little controversy exists regarding either the nonsurgical management of minor injuries or the emergency operative treatment of critical injuries.

SUMMARY

A study of 71 cases of renal trauma is presented. There were no deaths. On the basis of the simplified classification described, the incidence in the various categories was: 1) minor injury, 47 cases (66.2 per cent); 2) major injury, 23 cases (32.4 per cent); 3) critical injury, 1 case (1.4 per cent).

Severe, unassociated renal disease was found in 6 cases (12.8 per cent) in the group of minor injuries, stressing the necessity for thorough urological investigation in every renal injury encountered. Frequently, the decision as to proper therapy to be employed, based on accurate definition of the degree of injury, was reached only after retrograde studies had been done.

The average periods of immediate hospitalization for major injuries treated surgically (19.1 days) and nonsurgically (20 days) were approximately the same.

No complications or sequelae attributable to the trauma were found in 7 out of 9 patients with major injuries who were treated by early surgical intervention. The remaining 2 cases could not be contacted for follow-up studies.

In contrast, of 14 cases with major injuries that were treated initially by nonsurgical means, 12 (84.7 per cent) exhibited renal disease of severe proportions on the previously injured side. It must be emphasized that the extremely high incidence of major sequelae in this series does not necessarily represent the true incidence in all cases of major injury treated nonsurgically, since 11 of the 14 cases were seen at this clinic only because of their sequelae. However, it does constitute a significant reminder that medical treatment may result in major sequelae in a not inconsiderable proportion of such cases.

CONCLUSIONS

Proper management of renal injuries is based on early and complete utilization of all diagnostic facilities necessary to accurately determine the extent of the injury.

Early operative intervention is indicated in all instances of major and critical injury.

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