WAR INJURIES OF THE KIDNEY, URETER, AND URINARY BLADDER.

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Injuries of the urinary tract may be received under conditions which almost approximate those of peace time and also under circumstances inseparable from war. Penetrating wounds are the prerogative of passion; once upon a time accident alone engendered those injuries to the urinary system where no breach of belly wall exists. *Tout ça change*; modern aerial or artillery bombardments may rupture the abdominal viscera without external wound, and produce widespread blood or urinary extravasation. Such injuries may be the result of "blast" alone, or may be determined by the demolition and fragmentation of the wood, metal or masonry of edifices, which are hurled from their ensconcement against the abdominal parietes.

The damage produced by the modern engines and missiles of war rarely involves but a single organ; plurivisceral wounds are the rule; even more than one anatomical region may be implicated.

Wounds of the upper urinary tract threaten life less menacingly than do concomitant injuries of the intraperitoneal viscera, especially the hollow viscera, by which wounds of the kidney and ureter are often complicated. Save in cases of severest hæmorrhage, wounds of kidney and ureter rarely claim the first attention of the surgeon and often receive the scantiest of notice. On the other hand, bladder injury alike from penetrating wound or blunt force at once arrests attention and demands early surgical aid, if life is to be saved.

War Injuries of the Kidney.

Under conditions of warfare the kidney may suffer a subparietal contusion or rupture; on the other hand, it may be damaged by a penetrating wound of gunshot origin, and the writer has also met with an injury to the lower pole from impalement on a bayonet.

A contused kidney may be the only organ injured; sometimes the degree of renal damage is out of all proportion to the triviality of the injury; at other times, there may be severe complicating lesions, such as a fracture of pelvis, spine or skull, or a concomitant rupture of the spleen or other abdominal viscus.

The diagnosis of a subparietal injury to the kidney is not usually fraught with great difficulty; it is a far harder problem to estimate the degree of damage, to formulate a prognosis or to determine the appropriate treatment.

The pathological consequences of a renal injury and the resultant symptoms are intimately related (Fig. 1 Art Plate) to the *integrity of the renal capsule, the renal pelvis and the renal vessels*.

(a) So long as the tunic of the kidney is entire, renal damage consists of only subcapsular hæmorrhages; such patients almost without exception complain of pain in the loin which *does not tend to increase during the next 48 hours*. Tenderness is present in the flank in almost all, and in the hypochondrium in half the cases. Spasm of the flank muscles may also be demonstrated in about half the patients, but none of these *clinical signs become more obtrusive* as the hours and days pass by.

Hæmaturia is almost invariable, at any rate on microscopic examination, but disappears spontaneously in a few days. There can be no swelling in the abdomen, since capsule, pelvis and blood vessels are not torn. As a rule there is little or no shock; the pulse-rate and the blood pressure show little alteration; nausea and vomiting are absent; such cases require *no surgical exploration*.

(b) When the capsule has been divulsed, and the organ has undergone rupture, the clinical phenomena mentioned in the preceding paragraph are all more constant, more severe, *and often tend to increase in the first twenty-four hours*. The persistence of pain and the aggravation of other clinical signs and symptoms, *demand operative interference*, as also increasing tenderness in the iliac fossa and hypogastrium, and spasm of the psoas muscle. Such denote a spreading extravasation of blood, urine, or both; the size of any perinephric swelling that may be detected is some criterion of the degree of renal injury.

In patients in whom there exists no cogent need of urgent surgery, pyelography may be employed. Intravenous methods are simpler and less disturbing to the injured man; these will certainly show a depressed functional activity of the injured kidney, and on rare occasions may even demonstrate the escape of the medium into the perinephric tissues. Ascending pyelography should not be essayed in any intemperate haste, but performed carefully may furnish valuable data. Any marked disruption of the outline of the renal pelvis indicates gross renal damage, and any considerable escape of the pyelographic medium indicates a severe degree of damage.

No overweening confidence, however, should be placed in the results of pyelography; and more reliance should be reposed in clinical judgment than on one special instrumental investigation.

(c) **The renal vascular pedicle may suffer greater or lesser laceration.** Doubtless in most cases of complete traumatic severance of the vascular pedicle, death ensues immediately, but Prather (1940) has recently recorded a case in which this lesion had occurred and in which at subsequent operation a large smooth infarcted kidney was delivered out of the wound, with no attachment save the ureter.

Tears or contusions of the renal artery or its main branches have occasionally led to the formation of an aneurysm, or have determined an *infarct* of that part of the kidney supplied by the artery. The degeneration of a renal infarct is a not infrequent cause of secondary hæmorrhage from an injured kidney; the indications for surgery are more pressing if the case exhibits pyrexia.

The most important indications for surgical intervention are therefore: (1) cataclysmic hæmorrhage, and (2) a progressive aggravation of the clinical symptoms and signs of renal injury, during the first 48 hours. The value of blood-transfusion in such cases is inestimable. Early operation will render this service to surgeon and patient that, where possible, a deliberate conservative resection of the damaged portion of the kidney can be performed at a time when the urgency is not so extreme that only a total nephrectomy can be considered. Nevertheless where conservative operation carries any risk of consecutive secondary hæmorrhage, nephrectomy should be performed straightway.

The preservation of a damaged kidney may be ideal, but the surgeon's first duty is to save life.

The association of a ruptured spleen and ruptured left kidney from sub-parietal injury is infrequent but, as in complicated injuries of the kidney due to penetrating wounds, the prognosis and treatment depend largely on the damage to the other organs or structures implicated; thus, in a preponderant majority of cases the splenic lesion demands surgical intervention more cogently than the kidney. In one series of cases of combined renal and splenic injury the kidney presented at operation little more than a torn capsule, although in others the organ was ruptured, torn from its pedicle, even herniated through a rent in the peritoneum into the coelomic cavity. On the other hand, the spleen is almost always markedly damaged and beyond any thought of conservation. The prognosis manifestly becomes more grave if other structures are implicated, and in all these complex and complicated combinations of destruction, death almost inevitably ensues. In some of the cases reported by Desjacques (1930) of concomitant injury to spleen and left kidney there were fractures of the ribs on the left side; the liver was torn in four cases; even the opposite kidney was damaged in three, in one of which the spleen had been jettisoned by the trauma down to the right iliac fossa. The pancreas was torn in two, the diaphragm lacerated in another who died on the operating table; still another succumbed from his injuries, which included a fractured base of the skull. *Some men are fatally injured from the first*, but any surgery which fails to deal with the splenic rupture is doomed to failure in this associated injury.

Gunshot Injuries of the Kidney.

Several types and grades of kidney damage may result from gunshot injury; thus, a mere contusion may result from the passage of a missile nearby; perforations of the organ of variable size may be encountered, and in other cases the organ may be nearly bisected by a transverse rent. The superior or inferior pole of the kidney may be completely or incompletely torn off, and in others the body of the organ may be disrupted or pulped. (Figs. 2 and 3 Art Plate.)

Gunshot wounds involving both kidneys are invariably fatal, for in addition the spine is always implicated. Complicating damage to the contents of the spinal canal in addition to a gunshot injury to one kidney is not necessarily a mortal lesion, for the writer has operated upon at least two cases who survived severe hæmorrhage from a damaged kidney necessitating nephrectomy as well as an injured cauda equina, for which laminectomy was performed.

Any anatomical atlas furnishes a ready explanation of the frequency with which war wounds of the kidney are associated with injuries of other viscera. The illustrations contained in a recent paper by the writer (1940) or a few minutes' tour round the shelves of the War Office Collection in the Royal College of Surgeons are calculated to emphasize that kaleidoscopic vista of visceral injury that may prejudice the chances of recovery of any man who has received a gunshot wound of the kidney. *Plurivisceral injury augments mortality.*

The anatomical disposition of the structures in the thoraco-abdominal zone explains the probable frequency with which the thorax may be implicated in gunshot wounds which damage either kidney; indeed it was estimated that in 40 per cent. of kidney wounds investigated at an English Base in France during the war of 1914-1918 the thorax was injured. Museum collections illustrating concomitant damage of thoracic wall and contents as well as the abdominal organs, including the kidney might seem to bespeak the fatality of this type of gunshot injury, but on the other hand, the story of the gradual increase in recovery-rate from 18.5 per

cent. during the First Battle of the Somme in 1916 to 49.5 per cent. at the end of 1917 (Bowlby) demonstrated the conquest of surgery over a condition that at one time was regarded pessimistically. Nor did the triumphant progress stop at this figure; in the autumn of 1918, during the closing months of the last war, the writer collected the results of abdomino-thoracic injuries obtained by six surgeons in the Fourth Army, including his own, and found that the percentage of recoveries had actually risen to 66.6 per cent. *The immediate prognosis of abdomino-thoracic wounds is largely determined by the nature of the abdominal injury*; those accompanied by a wound of a hollow viscus proved very fatal.

In injuries of thorax and abdomen where the solid viscera of the belly, such as the kidney, were implicated, the outlook was more rosy, and in the Fourth Army series referred to above, Charles Saint, and the late John Anderson, who had the good fortune to encounter a relatively high percentage of solid viscus damage, had actually recovery rates of nearly 80 per cent.

Large blood vessels may be broached by the missile which injures a kidney; the writer dealt successfully with one case where a patient impaled himself on a bayonet, which transfixes his pelvic colon, divided his external iliac artery and damaged the lower pole of the left kidney.

In the preponderating number of cases the kidney injury played a minor part in endangering life and only rarely, for severe hæmorrhage or a hopelessly pulped organ, was primary nephrectomy indicated. In about 20 per cent. of the cases of gunshot wounds of the kidney, secondary hæmorrhage ensued at the Base, rendering secondary nephrectomy necessary, and about 20 per cent. of these unfortunates succumbed.

Secondary hæmorrhage may be consequent to sepsis, a retained missile, or to an infarct of the kidney produced by damage to some branch of the renal artery.

Despite the fact that the kidney usually plays a minor rôle in menacing life when damaged by gunshot injury in conjunction with other structures, a penetrating wound of the kidney demands inspection more frequently than is the case with subparietal injury. The wound down to the kidney should be excised, the organ investigated and any foreign body removed. Minor wounds of the kidney may be excised and sutured with satisfactory results.

Injuries of the Ureter.

George Neligan (1939) has emphasized the rarity of gunshot wounds of the ureter as observed in the "Forward Area," where injuries of more mortal character assume surgical prominence. Fig. 4 (Art Plate) illustrates an injury to the ureter which was associated with other wounds which caused a fatal result. (W.O. Collect. R.C.S.). All are agreed that in a few fortunate cases wounds of the ureter may close spontaneously; on the other hand, most run a risk of developing a ureteric stricture, infection, pyelonephritis or a pyonephrosis, necessitating nephrectomy if life is to be saved.

Adequate, even "voluminous" drainage and the extraction of any retained missile in the vicinity of the damaged ureter are of the highest importance. On no account should there be undue haste in removing the kidney, unless sepsis is virtually menacing life. Ureteric catheterization and dilation should be employed, and repeated lavage of the renal pelvis, if practicable, may be of value. By these

FIG. 1.—(7283.I. R.C.S. Museum). Right kidney which had been separated into two parts by a rupture which passes across obliquely slightly below its middle—from a man aged 20 who fell from his bicycle on to his right side in endeavouring to avoid a child. Operation performed three hours after admission to hospital.

FIG. 2.—Gunshot wound of lower pole of right kidney; there were concomitant injuries of the gall-bladder, death taking place from peritonitis.

FIG. 3.—(W.O. Collect. R.C.S. 1019). Left kidney showing disruption from bullet wound. The spleen has been removed by operation, but the missile had also damaged the descending colon and produced a large rent in the transverse colon. Death 16 hours after operation.

FIG. 4.—(W.O. Collect. R.C.S. 1042). Gunshot wound of left ureter. The patient died of associated wounds of coils of upper jejunum, stomach and liver.

FIG. 5.—Intraperitoneal rupture of bladder, due to the patient being crushed by two wheels of a wagon.

means a cure may sometimes be obtained, even in cases of renal dilatation and infection above a ureteric narrowing.

Injuries of the Bladder.

The bladder may be damaged by non-penetrating injuries (Fig. 5 Art Plate) as well as by penetrating wounds. *Subparietal damage to the bladder* is well recognised as a complication of fractures of the pelvic skeleton and as a result of blows upon the abdomen. The degree of distension of the organ and its liability to rupture are closely related in circumstances of trauma to the lower abdomen. The mention of bladder injury under conditions of warfare at once suggests a penetrating wound of that viscus, but the organ may also suffer subparietal injury under a variety of circumstances connected with modern warfare; fragments or masses of wood, stone or metal may be confusedly hurled with explosive force against the lower abdomen in air-bombardment; civilians and others may suffer tears of the bladder from falling masonry, and a vesical rupture may even be produced as the result of "blast" without any visible external sign of injury.

Injuries of the urinary tract have been said to occur in only 11 per cent. of *fractures of the pelvis* (Wakeley, 1929), but inasmuch as damage to bladder or deep urethra is almost entirely confined to certain types or mechanisms of pelvic fracture, the incidence of lesions of the urinary tract amongst those types of pelvic smash which are specially prone to produce resulting damage to the lower urinary system is considerably higher than the figure quoted. Injuries of the pubic portion of the pelvic ring and the combined disrapture of iliac and pubic portions of the pelvic girdle are those varieties of fractured pelvis which are specially liable to be complicated by a bladder lesion.

Suture of the bladder should always be performed where possible; this may often be impracticable, so that suprapubic drainage of the bladder has to be established. Adequate provision against subsequent urinary extravasation must always be secured. In some cases it may be impossible to approximate the two edges of the rent in the bladder, until reduction of the displaced and disrupted pelvis has been effected. In this type of fracture Watson-Jones has emphasized the value of manipulation in lateral recumbency, the patient lying on his uninjured side. It will probably be wiser to dispense with the double plaster spica and to rely on lateral recumbency, when bladder injury co-exists.

Gunshot Wounds of the Bladder.

The bladder may be wounded on its peritoneal aspect, but more frequently the rent is extraperitoneal; both types of injury may be encountered in the same patient, who is frequently found to have been shot in the buttocks, and in whom the missile has passed in an oblique and upward direction. Amongst the cases collected by a urological surgeon at an English Base in France in the last great war, 70 per cent. of bladder injuries of gunshot origin had the wound of entry in the buttock, 70 per cent. had the missile retained, and in 70 per cent. there was concomitant injury of intestine, bone or of both. Apart from the buttock, wounds of entry were also found in Scarpa's triangle, and lower down the thigh, the iliac fossa, groin, sacral and perineal regions. A suprapubic wound of entry was rarely encountered in gunshot wounds of the bladder investigated at the Base, doubtless because of the heavy mortality in the "Forward Area" from associated intestinal injuries commonly encountered in those wounded by a missile entering above the symphysis pubis.

Gunshot wounds of the bladder were occasionally through-and-through, and even of benign character. This fortunate course was most frequently seen in those who had an empty bladder perforated from side to side by a bullet or by a very small fragment of high explosive; a slight hæmaturia or a little trickle of urine from the wound might alone betray the bladder injury. Certain of these more fortunate individuals underwent no operation, and were able to leave hospital at an early date. In other cases, subsequent discovery of a foreign body in the bladder was the first indication of a previous wound of that organ, although the missile may well have primarily lodged in the perivesical tissues and have only later made its way into the interior of the viscus. *Intraperitoneal wounds* of the bladder of gunshot origin are most frequently discovered at laparotomy, but some warning of its involvement may have already been forthcoming in the form of such clinical manifestations as hæmaturia, difficulty in micturition, etc. The bladder should be sutured whenever the condition of the patient and the accessibility of the vesical wound render this possible. *Intraperitoneal wounds* present no difficulty, unless the rent is situated at the bottom of the pouch of Douglas; *extraperitoneal wounds* may be relatively inaccessible, and their suture less certain. In situations where the art and skill of the operating-theatre manufacturer are not available, some improvisation may be required to obtain the Trendelenburg position; this sometimes involves undesirable expenditure of time and temper. Where suture is deemed impossible, a self-retaining suprapubic tube may be introduced, and the vicinity of the extraperitoneal wound must be drained by corrugated rubber sheeting. An indwelling catheter passed per urethram has drawbacks in the transport of wounded men, and the risks of severe urinary sepsis are greatly augmented under conditions of warfare.

When bladder and pelvic rectum are both wounded, suture of each viscus must be performed. *In injuries of the perineal rectum and the extraperitoneal part of the bladder* suture is ideal, but may be difficult or impossible. Sometimes the condition of the patient, the site of the communication and a favourable surgical environment may suggest a transvesical approach to the lesion; the writer successfully dealt with two cases in this way.

In most cases of recto-vesical injury, however, the surgeon must content himself with adequate perineal and suprapubic drainage of the tissues of the pelvis in addition to a suprapubic cystotomy. The performance of a "double-barrel" transverse colostomy may seem desirable in some cases; this at least can be easily closed.

To secure adequate drainage of the extraperitoneal tissues of the pelvis, the coccyx may sometimes require removal. In certain recto-vesical wounds involving the ampullary rectum the sphincter ani may be divided with advantage; in others the muscle may be stretched. In the early hours after wounding the surgeon's activities must be directed to the saving of life by the most adequate drainage methods.

If prophylaxis fails, or if infection of the vulnerable post-rectal tissues is already established, especially if it be complicated by a compound fracture of the sacrum, disaster will indubitably follow. *Ruthless provision for drainage must therefore be made*; the art of the proctologist and the urologist may be demanded later in order to restore the normal function of damaged anatomical structures.

The female perineum is nowadays no safer from damage by high explosive than is that of the soldier in the field. The gentle art of indiscriminate bombing

which the "Boche" so sedulously practised in his Spanish playgrounds and perfected in the shambles of Poland renders women-folk in shop or ship, in home or hospital, liable to injuries of bladder, vagina, and rectum from the missiles of air-attack. The alterations in the form and relations of the bladder during pregnancy and the forces to which the viscus is exposed during parturition make the female bladder specially vulnerable at this period.

The dependent position of the wound fortunately promotes natural drainage; the art of the gynæcologist and plastic surgeon will doubtless be needed to restore function in such as survive the murderous attacks of "les sales Boches" or the foul Red brood of Stalin.

According to writers on the surgery of the war of 1914-18, the prognosis in cases of *bladder injury accompanied by intestinal wounds*, was dismal in the extreme. The following table modified from one included in the Official History of the "Great War," confirms the serious character of this plurivisceral form of wounding:—

Bladder Injuries WITHOUT Damage to other Viscera.

Intraperitoneal Injury	...	...	...	5 cases	Mortality = 60 per cent.
Extraperitoneal Injury	...	...	...	20 cases	Mortality = 55 per cent.

Bladder Injuries associated WITH Damage to other Viscera.

Bladder + small Intestine	...	...	...	12 cases	} Mortality = 93 per cent.
Bladder + small Intestine + Colon or Rectum	...	...	...	2 cases	
Bladder + Colon or Rectum	...	...	...	4 cases	—probably all fatal.

It has been tentatively suggested that the greatly increased mortality in cases operated upon for intestinal and bladder injury over that attending the surgical treatment of intestinal injury alone may have been related to the greater expenditure of time in securing a good bladder-suture at the end of a time-consuming intestinal operation.

This gloomy and pessimistic attitude towards associated bowel and bladder injury was not altogether justified in the writer's experience. For example, one patient recovered who had received a penetrating wound of the abdomen which had involved the bladder, bowel and bone. There was an extrusion of shattered small intestine about three feet long, and another segment of small bowel inside the abdomen was also badly damaged. The missile weighed nearly a quarter of a pound, and was firmly impacted in the pubic bone; the fracture of a rib and of part of the iliac crest and considerable destruction of the abdominal wall completed the tale of injury due to the fragment of high explosive. As the result of an operation which necessitated a double resection of bowel and the repair of bladder and other lesions, the patient recovered. (G-T.)

Another patient operated upon by the author survived a gunshot wound of bladder, rectum and small intestine, including a penetrating injury of a Meckel's diverticulum. The missile was found to have entered the right buttock and to have opened the right side of the perineal portion of the rectum about $2\frac{1}{2}$ in. from the anus; it had then traversed the right infero-lateral extraperitoneal wall of the bladder and emerged from the peritoneal surface of this viscus at the junction of the superior surface and the base. The track between the rectum and the buttock was laid widely open, the sphincter divided and adequate perineal drainage thus secured. The wound of the peritoneal surface of the bladder was excised, and the edges were sutured with catgut; the cave of

Retzius was drained with a piece of rubber sheeting. There were sixteen perforations of the ileum and several holes in the mesentery; two of the wounds in the bowel were along the mesenteric attachment. There were also two small wounds in a Meckel's diverticulum which was present. It was deemed necessary to resect one damaged portion of the ileum, and the resection was extended downwards so as to include the portion of bowel to which the diverticulum was attached; $3\frac{1}{2}$ ft. of small intestine was removed, and an end-to-end junction was made. The man survived.

Two surgical colleagues of mine during the last war have also reported recoveries after extensive bowel-resection and repair of bladder injuries; Gordon Bell, now of Dunedin, saved a 5 ft. small bowel resection, in whom the bladder and rectum were also sutured, while D. C. Taylor successfully resected 4 ft. of small bowel and removed a fragment of shell from the bladder. There is a specimen in the War Office Collection in the Royal College of Surgeons of a piece of small intestine which proudly commemorates a successful resection of bowel in a man whose bladder had also been sutured.

The anatomical relationship of the bony pelvis to the urinary bladder explains the great frequency with which *osseous lesions accompany gunshot injury of this viscus*. Sometimes the damage to the pelvic girdle is the one concomitant injury present; others have suffered plurivisceral wounds in addition to skeletal damage; the rectum, pelvic colon and small intestine are the hollow organs most often injured, when there is a penetrating wound of the bladder.

In Fullerton's series investigated at an English Base in France in the war of 1914—1918, no less than 40 per cent. of bladder injuries were complicated by damage to the pelvic girdle; French urological surgeons gave even a higher percentage. Military surgeons are unanimous that the pubic portion of the pelvic girdle is that most frequently damaged, but no segment of its bony circumference is immune; the proximity of this part of the innominate bone to the bladder doubtless explains its special proclivity to concomitant injury. The anatomical character of lesions of the pubic bone are protean; these may be unilateral or bilateral; horizontal or ascending ramus may be shattered, or both rami may be fractured along with the body of this bone. The symphysis may also be implicated by the track of a missile traversing the os pubis.

The severity of the osseous injury will of course vary; in some the bone may be merely perforated; in some the margin of the ramus may only be notched, while in others a bursting effect is produced, fragments and spicules of bone being perchance driven into the cavity of the bladder. The propinquity of the spermatic cord renders it liable to injury or division, and the vitality of the testicle may be gravely endangered.

Osseous rarefaction in the vicinity of the track of the missile through the pelvic girdle may determine an alteration in the anatomical conformation and the architecture of the bone, and the gradual dilapidations of pathology may be augmented by the surgical ablation of sequestra which invite removal during any exploration of the wound.

Sequestra from a damaged innominate bone may make their way into the cavity of the urinary bladder; they may be found coated with phosphatic incrustations, and may be responsible for the foul, malodorous urine and for the persistence of a bladder fistula.

It is with an extraperitoneal wound of the bladder that concomitant damage to the pelvic girdle is most frequently associated; bony damage augments the risk and the severity of sepsis. The usual history of such cases is a prolonged discharge of urine and pus from the wound made by the missile, or from orifices which have opened on to the skin of the groin, perineum or thigh as the result of the diffusion of the infection, or which result from incisions made by the surgeon to facilitate drainage.

The suppurating track through the bone from skin to bladder may assume a "shirt-stud" character; on the other hand the extravasation of urine and pus may spread widely outside and inside the bony pelvis. The co-existence of a communication between the bladder and rectum will increase the infectivity of a track which now involves "skin and bone," "wind and water."

Post-operative care of the drained bladder and special heed to the psychological moment for removal of the drain are almost as important as the early performance of suprapubic cystotomy.

The late stages and sequelæ of injuries of the urinary tract have been deliberately omitted from this communication, but the surgeon should remember that a gunshot wound of the os pubis, especially if complicated by suppuration, may be followed by an adhesion of bladder to bone, whereby the proper evacuation of the bladder is interfered with.

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