COMPLICATED CRUSHING INJURIES OF THE PELVIS

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In the last two years we have seen seventy-five cases of pelvic girdle injuries with soft-tissue complications in patients admitted to the hospitals serving the African population of Johannesburg and its environs. These injuries had been caused by motor vehicle accidents, railway accidents, falls from heights, and assaults. Twenty of the patients died from their injuries, eight of them within four hours of admission to hospital, and five within forty-eight hours. Multiple injuries, shock, and major head injuries contributed to the early deaths.

Watson-Jones (1938) compared the bony injuries sustained by the crushed pelvis to the hinge-like opening of an oyster. The element of surprise associated with the opening of oysters is also present in the diagnosis of soft-tissue and visceral injuries in patients with pelvic fractures. Wakeley (1929) encountered eleven visceral injuries in his series of 100 pelvic fractures. Watson-Jones (1938) classified the morphological types of pelvic fracture and commented on only two cases of urethral disruption in 143 pelvic fractures. In 1948 Holdsworth described fifty patients with pelvic fractures, of whom four had urethral injuries and eight had retroperitoneal haematomata large enough to warrant special mention. Kisner (1958) reviewed nearly ten years' experience of urethral injuries in our hospital group; he described eighty-seven urethral injuries in a group of 442 pelvic fractures.

In this series we consider only those patients with injuries complicating the pelvic fractures. Most patients had additional injuries ranging in severity from a Colles's fracture to fracture-dislocation of the cervical spine with tetraplegia.

GENERAL PRINCIPLES OF MANAGEMENT

The airway has received first priority in patients who have sustained "run-over" injuries (Froman 1964). Adequate ventilation has been ensured by clearing the airway, by intubating the patient, by tracheostomy, by compensating for a flail chest wall with intermittent positive pressure ventilation, or by relieving a tension pneumothorax. After this the blood volume has been restored, by saline, plasma, intravenous bicarbonate, or liberal transfusions of whole blood. In addition, we have routinely given hyperosmolar intravenous fluids (Mannitol 100-200 millilitres of 25 per cent solution) as early as possible in resuscitation to facilitate early and adequate diuresis. This diuresis ensures bladder lavage and patency of catheters. It is prophylactic against renal tubular necrosis which may follow the triad of shock, acidosis, and large volumes of acid-citrate-dextrose blood transfusion (Moore 1963). Renal failure caused the death of two patients at the beginning of this series. Neither of these patients received hyperosmolar infusions. We had no further cases of renal failure after routine prophylaxis with hyperosmolar infusions was instituted.

Once fractures had been immobilised, bedside radiographs of the chest, pelvis and relevant skeletal injuries were taken. The pelvic radiograph usually was coupled with simultaneous contrast medium radiography. At this stage the patient's general condition was temporarily stabilised, and a repeated, more leisurely, complete clinical examination was undertaken. This is essential for the establishment of a baseline for the evaluation of changing abdominal, respiratory and intracranial symptoms and signs. Other injuries which had been missed initially have become patent at the time of review.

Operation on urinary tract injuries and fractures may be delayed for one to two hours, until all the facets of injuries which we have discussed have been dealt with adequately.
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RETROPERITONEAL HAEMORRHAGE

It is inevitable that any pelvic fracture produces a retroperitoneal or extraperitoneal haematoma. It is the size of this haematoma which is important. It may be as large as 2,000-3,000 millilitres and is rarely less than 500 millilitres. The source of the bleeding may be the medullary cavity of the fractured bones, or torn pelvic and lumbar vessels. The precise source of bleeding cannot always be defined even at post-mortem. However, we have seen a patient succumb with complete disruption of the pedicle of the right kidney, and in two other instances the common iliac veins were found at laparotomy to be torn. Rupture of the femoral artery and vein accompanied anterior dislocation of the hip joint in one patient. At necropsy, even without such a frank source of haemorrhage, it is usually noted that the haematoma fills the pelvis, envelops the bladder and rectum, tracks up the retroperitoneal space and discourts the kidneys, the retrohepatic area, and the posterior half of the diaphragm. Clinically, bruising stains may be seen expanding upwards on the anterior abdominal wall from the inguinal ligaments to the umbilicus. This may be associated with a boggy oedematous consistency of the lower abdominal wall. At a later stage fluid accumulations may present as large cystic swellings in the gluteal and lumbar regions. These liquefied haematomata occurred ten to thirty days after the injury in one third of our cases. They were fluctuant and non-tender, and brown serous fluid up to 2,000 millilitres in volume was obtained on aspiration of some of the larger cysts.

TABLE I

| The Six Types of Pelvic Fracture |
|-------------------------------|-----------------|
| Type                          | Number of patients |
| Isolated fractures            | 6               |
| Fractures of the pubic rami   | 18              |
| Diametric fractures of the pelvis | 13          |
| Diametric fractures of the pelvis with displacement cranially of the hemipelvis | 8 |
| Fractures of the pelvis complicated by acetabular fractures | 17 |
| Fractures of the pelvis associated with fractures of the femur | 11 |

The retroperitoneal haematoma is responsible for further complications besides those associated with oligaemic shock. In its signs it may simulate closely an intraperitoneal visceral injury. There may be reflex abdominal muscular spasm, with guarding, rigidity and tenderness, and paralytic ileus may develop. Repeated examination during the ensuing four to six hours is essential, and then, on occasion, the diagnostic problem may be resolved only by laparotomy. Laparotomy in a patient with multiple injuries is not without morbidity and mortality, and should not be lightly undertaken. Laparotomy increases the likelihood of ventilatory inadequacy, diaphragmatic "splinting", and disturbance of basal pulmonary ventilation. At laparotomy it has been our practice to determine the size of the haematoma, and unless it rapidly increases we have usually left it alone; only rarely have we drained it. In five patients pelvic sepsis occurred, and in three of these cases the infection followed drainage of the haematoma. The other two instances were associated with rupture of the rectum.

FRACTURE PATTERNS

We have divided the radiological appearances of the pelvic fractures which we have seen into six types (Table I). (Two children with "run-over" injuries, both with rectal disruptions, showed no pelvic fracture.) This classification is an amplification of that described by Watson-Jones (1938). Holdsworth (1948) first drew attention to the fractures associated with cranial
displacement of the hemipelvis. The mechanism of acetabular damage, and fracture of the femur in run-over injuries, has been clarified by Dommise (1960). We have added the latter three groups to Watson-Jones's original triad.

The pelvis may be fractured by direct force, by compressing forces, or by transmitted impacting or torsion forces. These classifications are relevant to the categorisation of a series of radiographs. They are of some practical value in that they may demonstrate the easiest routine method of reduction. However, a patient with a crushing injury has been subjected not to a single direct force and not to a single transmitted force, but rather to a conglomeration of multiple forces acting in multiple moments. In addition, there is a shearing component on soft tissues, producing skin and soft-tissue damage. Every patient, therefore, has a fracture pattern of his own, and each injury must be treated on its own merits. The fracture may be treated by open reduction (Dommise 1960; Judet, Judet and Letournel 1964) or by manipulation (Armstrong 1948) or it may be ignored. The condition of the patient, the degree of abrading, of contamination, of flaying of the flesh and the necessity for dealing with visceral injuries as a priority, will determine whether the deformity must be accepted for the interim or be dealt with by early open reduction.

Sciatic paralysis is nearly always due to a displaced fragment from the back of the acetabulum. If the fragment does not fall into place after manipulation open reduction should be done in order to relieve compression of the nerve (Armstrong 1948; Haw 1965). We have seen five patients with sciatic nerve palsy. In four there was no recovery of function. Operation had not been undertaken because of multiple injuries.

Fractures of the sacrum commonly accompany pelvic fractures (Bonnin 1945). Recognition of sacral fracture is most easily ensured by inspecting the continuity and regularity of the arches above the anterior sacral foramina and comparing them with those at the opposite side. Sacral fracture may be the site of cauda equina root compression, and may cause persistent low back pain (Fig. 1).

**Fig. 1**

Radiograph of a sacral fracture associated with neurapraxia of the right lower sacral segments. After twelve months there was full recovery of the motor and sensory function.
URETHRAL AND VESICAL INJURIES

These injuries fell into two groups: 1) rupture of the posterior urethra (29 patients); and 2) intraperitoneal rupture of the bladder (14 patients). Disruption of both bladder and urethra was found in two other cases.

We have seen no case of bulbourethral injury in this series. Our patients sustained crushing injuries rather than injury to the perineum by direct contusion.

It is difficult to correlate the fracture pattern with the presence of bladder or urethral disruption. An ilial blade fracture may be associated with bladder disruption, whereas wide diastasis of the symphysis may not cause injury to the urinary system. Rupture of the urethra may show obvious diagnostic features. However, the diagnosis may not be so apparent in the unconscious patient. In three instances bleeding per urethram was from the kidney, and there was no urethral discontinuity. Rupture of the bladder may be missed for a considerable time with unfortunate results. The passage of a catheter into the bladder and the free drainage of urine is no guarantee that the bladder is intact. Pressure on the paracolic gutters rather than pressure over the suprapubic region may elicit a free flow of urine from the catheter. This may indicate a ruptured bladder, with intraperitoneal accumulation of urine, but this sign may be falsely interpreted. Routine contrast radiography is a far safer diagnostic procedure. We have used the following routine in the management of patients with pelvic fractures. A soft polythene tube was introduced into the urethra and 20 millilitres of 30 per cent Urographin injected. If urethral disruption was not shown on the radiographs the catheter was then passed into the bladder. If there was still the least doubt of the integrity of the bladder, 200 millilitres of contrast medium were injected into the bladder and the radiographs were repeated. Radiographs may show the following appearances: the bladder may fill evenly, or may show a "pear drop" pattern because of displacement by perivesical and intravesical haematoma. There is no guarantee that the bladder is intact when it appears fully distended with contrast fluid, as a posterior rupture with a valve-like tear in the bladder wall may be present. An antero-posterior radiograph of the upper abdomen and a lateral view of the pelvis should be taken. If there has been even slight leakage of the contrast medium into the peritoneal cavity the contrast medium will outline bowel loops in the paracolic gutters. Repair of the bladder or urethra should then be done. There is no place for interim suprapubic urinary diversion without urethral reconstruction (Poole-Wilson 1954, Trafford 1955).

DAMAGE TO THE ANUS AND RECTUM

Reports of rectal and anal disruption in run-over injuries are few (Chunn 1958). We have seen twelve patients in whom crushing injuries have been complicated by the tearing of the anal canal or laceration and perforation of the rectum. Four of these patients have been reported previously (Stein 1964).

The injuries are of four types: 1) a linear laceration extending from the anal verge to the mid-rectum, or extending intraperitoneally; 2) extraperitoneal laceration of the rectum in the anterior wall at the point of attachment of the recto-vesical septum, usually associated with disruption of the posterior urethra; 3) intraperitoneal rupture of the rectum; and 4) ano-rectal avulsion with circumferential separation of the mucosa from skin. The rectum may then prolapse, or it may be drawn up into the sacral hollow.

The rectum may be torn by a bony spicule, or it may be damaged by forcible compression against the sacral promontory. Avulsion injuries are more likely to be caused by an explosive change in intra-abdominal pressure brought about by crushing forces. Two of the twelve patients were children under three years of age, who were run over. In neither was there evidence of a pelvic fracture, yet in both there was complete rectal avulsion and prolapse. Wakeley (1929) asserted that the absence of pelvic fracture in a similar case was due to the elasticity of the pelvis as a whole—a characteristic which is notable in young subjects. Two
patients with rectal perforation presented with pelvic abscesses two weeks after injury and only then was it realised that there had been a rectal injury.

Anal and perineal wounds were debrided and sutured, and sphincteric mechanisms were reapposed by interrupted silk sutures. Diversional colostomy was done without hesitation if wounds were extensive, and we did this in nine of our twelve cases. Despite diversional colostomy two patients developed faecal fistulae of the anterior abdominal wall (Fig. 2).

Of the twelve patients who sustained ano-rectal injuries, nine had associated urinary tract injuries; six had urethral ruptures, and three had vesical ruptures.

**OBSTETRIC AND GYNAECOLOGICAL INJURIES**

**Pregnancy and pelvic fracture**—We have seen pelvic fractures in four patients who were in the last three months of pregnancy. Foetal death had occurred in three of them at the time of admission to hospital. One mother was moribund and died. Two mothers had vaginal deliveries of still-born babies, and recovered. The fourth mother presented a more complicated picture (Figs. 3 and 4). She was aged twenty-three, and thirty-four weeks pregnant. She was severely shocked, but the foetal heart was audible. The left hip was dislocated, and there was a quadruple fracture of the anterior pubic segment. A catheter introduced into the bladder released a little bloodstained urine. At operation, a large retroperitoneal haematoma was found, and there was an intraperitoneal rupture of the bladder. The uterus was intact, and showed no bruising. Foetal movements were sporadic, and the foetal size was assessed as three pounds. The abdomen was closed and the patient was returned to the recovery room. Ninety minutes later the patient went into precipitate labour, which lasted for four minutes. A copious flood-like haemorrhage followed after the still-born child, and the mother died within a few minutes. The child was grossly anaemic, and there had obviously been placental detachment and the infant and mother had been exsanguinated. It might have been best to undertake Caesarean section at the time of laparotomy.
Gynaecological injuries—Two patients had vaginal perforation by bone from fractures of the pubic rami. In one the vagina was lacerated and a fragment from the posterior part of the pubic ramus was found in it. Healing was rapid and there were no sequels to the injury. The other one was bleeding through the vagina. On examination blood and free flow of urine were found in the vagina. A fragment of pubic ramus had made a vesico-vaginal fistula. Posteriorly, there was a third-degree tear of the vagina, extending into the rectum, and there were linear perineal lacerations. The vaginal and perineal lacerations were sutured and the vesico-vaginal fistula was repaired by an abdomino-perineal approach. An indwelling catheter was left in the bladder for ten days. When she was seen six months later the vaginal canal was still indurated and distorted, but there was no evidence of a urinary fistula.

PERIPHERAL NERVE INJURIES

Localisation of the level of nerve lesions in patients showing sensory and motor loss in the lower limbs is difficult. Lam (1936) reported nine patients with nerve lesions in a series of 100 pelvic fractures. However, review of these cases suggests that some of his patients, particularly those who dated their symptoms long after injury, did not suffer from pelvic distraction of nerves but from lumbar disc herniation with root compression. It is possible that the force which caused pelvic fracture also contributed to disc prolapse.

Bonnin (1945) described how the sacral roots may be involved by stretching or by haematoma, fibrosis or callus, or impingement of bony fragments in sacral fractures which run through the first and second sacral foramina. He reviewed five patients and commented that these nerve lesions may be differentiated from intrathecal compression of the roots at higher levels by the absence of local pain.

Patterson and Morton (1961) reviewed five cases, and examined ten other cases of peripheral nerve injuries. Their series demonstrates the difficulty of localising the injury, and
several of their cases suggest a diagnosis of lumbar disc protrusion. We have found that the diagnosis is usually made when the patient is in the recuperative phase. We have recorded five instances of transient paresis which showed full recovery at three months. Five other patients, one of whom had bilateral paralysis, remained with a persistent neurological deficit. These five patients are briefly reported.

CASE REPORTS

Case 1—A woman of twenty-one with multiple injuries and a fractured pubic ramus and upward displacement of the hemipelvis developed a total right lumbar second, third and fourth root lesion. Anaesthesia was present over these segments. There was quadriiceps and adductor wasting, with complete loss of power. After three months she began to develop genu recurvatum, but she refused to wear her caliper. Electromyography demonstrated total nerve disruption. She developed deep venous thrombosis in the right leg, and had an episode of pulmonary embolism. She was therefore maintained on an anticoagulant regime. She was loath to submit to any operative procedures, and the opportunity was never available to explore the area of nerve damage.

Case 2—A man with acetabular central dislocation and sacral fracture showed a lumbar 4-5 loss on the right side, and a sacral, 1, 2 and 3 loss on the left. There were no signs of recovery after six months and he has had to wear boots and calipers ever since.

Cases 3 and 4—Two patients had unilateral loss of the fifth lumbar and first sacral dermatome sensory and motor groups. Both were subjected to myelography, which was not helpful, and the site of the nerve injuries remains undetermined.

Case 5—The fifth patient with a peripheral nerve injury other than sciatic palsy showed a persistent right lumbar 4 and 5 cutaneous analgesia and motor loss. The pathology of lumbar and lumbo-sacral nerve plexus lesions of this nature should be equated with the pathology of the more common traction injuries of the brachial plexus. The damage is probably disseminated over a length of the nerve which has been subjected to tearing stresses, and, unless recovery occurs rapidly and spontaneously, there would appear to be little hope for successful surgical intervention.

There is one further related aspect of nerve injury in pelvic fracture. We have found that the incidence of impotence in male patients with posterior urethral disruptions is high. About half of our twenty-nine patients complained of impotence. We have had to rely on subjective histories from which to draw our conclusions, and have not yet had a sufficiently long follow-up period to draw statistical results. Previous reports in the literature (Trafford 1955, Chambers and Balfour 1963) suggest that between 15 per cent and 25 per cent of these patients may remain impotent.

INJURY TO THE SOFT-TISSUE PARIETES

Crushing forces to the pelvis may damage overlying skin and soft tissues by shearing forces which may fray the skin from fascial layers or, more severely, they may produce dehiscence of the skin and underlying muscles. Disruption of the integrity of the parietal walls with dismemberment may follow.

Four patients suffered large areas of skin sloughing due to tyre wheel flaying. One patient died of septicaemia as a sequel to osteomyelitis of the pubic bones which followed their exposure by extensive sloughing of the skin of the lower abdominal wall.

Two patients sustained anterior abdominal wall damage with dismemberment. One lay in the roadway in an alcoholic coma, and a car travelling at speed passed over his midriff. The left iliac blade was comminuted and a large rent torn in the muscles, fascia and skin of the left flank. The abdominal viscera herniated through the defect, and the bladder was ruptured. A primary repair was made, which required subsequent split-skin grafting. His recovery was uneventful.

Less fortunate was the individual who fell under a moving train, the wheels of which disarticulated his left hip. The pelvic bones were fractured in several places and his intestines herniated beneath a bare inguinal ligament. Resuscitation was attempted and when a blood pressure was recordable the disarticulation was completed at operation. The bladder
was ruptured, the external iliac vessels torn across, and the rectum was disrupted. The left ureter was avulsed from the bladder. A colostomy was done, the ureter reimplanted, and the bladder was drained. The patient died three hours later.

The most distantly related injury to pelvic compressive forces is that of diaphragmatic rupture. The same explosive effect of abdominal compression which produced a rectal "blow-out" may produce a tear in the diaphragmatic roof of the abdominal cylinder. We have had two such patients. In one, there was no chest injury apparent at the time of admission, and the fact that his colon had herniated into the left pleural cavity only became apparent the following day, when he had become dyspnoeic and cyanosed.

CONCLUSIONS

We have attempted to systematise the injuries associated with pelvic fractures. Such a systematisation and classification of the injuries sustained is only a matter of convenience. Potentially, any or several of the systems listed may be involved in any one patient. In addition, four in five of these patients will have other injuries not immediately related to the pelvis, but sustained during the same accident. Efficient management which will least prejudice those natural faculties for recovery is essential. Accident services, both urban and rural, must be organised to deal with the early resuscitation of the injured, and to facilitate early diagnosis of the multitude of apparent and occult injuries which may have been inflicted.

We stress the variety of injuries concomitant on pelvic fracture, in the hope that attention to these injuries will be improved by an awareness of them.

SUMMARY

1. Seventy-five patients sustained fractures of the pelvis with associated soft-tissue complications. Twenty died, and of these, thirteen died within forty-eight hours of admission to hospital.
2. The initial resuscitation and clinical assessment of these patients are discussed, and attention is drawn to the significance of the concomitant retroperitoneal haematoma as a cause of oligaemic shock, and as a dissembler of internal visceral injury.
3. The morphological fracture patterns are classified into six categories, but the fracture patterns are not correlated with specific visceral injuries.
4. Forty-six patients sustained urinary tract injuries. Of these, nineteen had suffered rupture of the urethra; fourteen had rupture of the bladder; two had both urethral and vesical disruption, and one patient had a torn ureter. The diagnosis and management of these injuries is discussed.
5. Twelve patients had a traumatic laceration or perforation of the ano-rectum. Nine of these patients had associated urethral or vesical injuries.
6. Four patients were involved in accidents and sustained pelvic fractures while in the last three months of pregnancy. The tragic outcome of this combination of circumstances is noted.
7. Attention is drawn to peripheral nerve injuries in association with pelvic fractures, and the difficulty of localising these lesions is stressed.
8. Eight instances of damage to the abdominal parietes are recorded. Four patients suffered skin and soft-tissue loss, two patients had diaphragmatic disruptions and two patients had abdominal wall dehiscences.
9. Major accident victims frequently have multiple injuries. This series of patients has been analysed to draw attention to the association of pelvic fractures with bizarre visceral injuries.

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