PATTERN OF PELVIC TRAUMA AS SHOWN BY VARIOUS IMAGING MODALITIES IN NAIROBI, KENYA.

PROSPECTIVE STUDY DONE AT KENYATTA NATIONAL HOSPITAL AND THE AGA KHAN HOSPITAL, NAIROBI

FROM MAY, 2001 TO DECEMBER 31, 2001

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UNIVERSITY OF NAIROBI

BY

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A DISSERTATION ON

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DECLARATION

Candidate

I, Dr Humphrey Kiwelu, declare that this dissertation is my own original work, and that it has not been presented to any other university for similar or any other degree award.

Signature.............................. Date 16·05·2002.............................

Dr Humphrey Kiwelu

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Supervisor

This dissertation has been submitted for examination with my approval as a university supervisor.

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TABLE CONTENTS

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ABBREVIATIONS

AP	Anteroposterior
ARDS	Adult Respiratory Distress Syndrome
ASC	Ascending Cystourethrography
CT	Computed Tomography
Fig.	Figure
IVU	Intravenous Urogram
KNH	Kenyatta National Hospital
L5	Fifth Lumbar Vertebral
MCA	Motor Cycle Accident
MCU	Micturation Cystourethrography
MRI	Magnetic Resonance Imaging
MVA	Motor Vehicle Accident
RNS	Radionuclide Studies
RTA	Road Traffic Accident
S1	First Sacral Vertebral
SIJ	Sacroiliac Joint
STI	Soft Tissue Injury
U/S	Ultrasound
USA	United States of America

ABSTRACT

Prospective study was carried out at Kenyatta National Hospital and the Aga Khan Hospital-Nairobi for eight months, to establish the pattern of pelvic injuries and possible associated soft tissues injuries as shown by various imaging modalities in Nairobi – Kenya. One hundred and eighty nine patients were studied.

The study group included one thirty six (72.0%) males and fifty-three (28.0%) females: The age distribution was from 0 – 80+ years and this followed a normal distribution curve.

The most frequent pelvic fractures were the fractures of ischiopubic rami, ninety-seven (51.3%) followed by acetabulum fractures, sixty-four (33.9%). Among the patients with pelvic fractures, six (3.2%) had ruptured urinary bladder and twenty-four (12.7%) had ruptured urethra. Of all patients seen, 12.2% had normal results in plain pelvic radiographs and CT Scans.

The most common imaging modality used was plain radiography, one eighty-six (98.4%). In twenty-six (13.8%) patients both CT Scan and plain radiography were used to establish the diagnosis.

The most common cause of pelvic injuries were Road Traffic Accident, one fifty three (80.9 %) followed by fall from height, twenty-three (12.2%) and other causes like gunshots, assault, and rape added up to thirteen (6.9%).

INTRODUCTION

Injuries of the pelvis include the skeleton and soft tissues. These can present with various clinical problems. Some pelvic fractures are relatively minor and occur with minimal trauma, particularly in the elderly. A major pelvic injury, however, may be fatal, as it has the potential to cause massive haemorrhage and damage to pelvic organs. Patients' condition should then be stabilised before the radiographic examination is performed

Pelvic injuries are often caused by high velocity road traffic accidents, and involve drivers, passengers and pedestrians (1). Accidents, which occur in heavy industry and falls, may also cause major pelvic bone and soft tissue injuries.

The mortality of the patients in pelvic trauma, has been reported to range from 16% to 60% and is related to primary pelvic injury and to distance related injuries, mostly visceral or cerebral (2). The increasing incidence of trauma to the pelvis has paralleled the increase in automobile and motorcycle accidents and it is reported to be major cause of death in victims of multiple injuries (8).

Pelvic fractures may be categorised into;

- Fractures of individual bones
- Disruption of the pelvic ring.
- Fractures of the acetabulum

Fractures involving individual bones include;

- An avulsion injury of an iliac spine or ischial tuberosity
- Single pubic ramus fracture
- An isolated fracture of an iliac wing, sacrum or coccyx.

Disruptions of the pelvic ring include;

- Stable pelvic fracture which consists of single break in the pelvic ring or disruption of the margin of the ring
- Unstable pelvic fracture, which consists of two or more, breaks in the ring.

Fractures of the acetabulum include;

- Anterior acetabulum fracture
- Posterior acetabulum fracture
- Central acetabulum fracture
- Complex acetabulum fracture

The rapid and correct diagnosis of pelvic fractures and more specifically, the type of pelvic fracture and associated soft tissue injuries like vascular, urinary bladder and others are of great importance for better patients' management. Evaluation of pelvis, especially pelvic fractures by conventional radiography has been difficult because of superimposition of various shadows, but with the arrival of Computed Tomography Scanners in 1972, has shown great advantage over plain conventional radiography. Although Computed Tomography Scan is more expensive, advantages out weigh this over conventional radiography. It has high resolution in delineating fracture, extent and any associated soft tissue injuries. Spiral Computed Tomography is faster, covers a wider area and gives fine sections.

Computed Tomography Scan is relatively available in more hospitals in Kenya, and is indicated when the plain radiograph is equivocal, or soft tissue injury is suspected. It is therefore the conventional radiography and Computed Tomography Scan that are used in imaging of pelvic trauma. In developed countries spiral Computed tomoghaphy, is the examination of choice in pelvic injuries. It is time saving and provides more information for both skeleton and soft tissue injuries.

Magnetic Resonance Imaging (MR1) is expensive and unavailable for most patients in Kenya and therefore was not considered in this study.

RATIONALE

Pelvic trauma is important because it is associated with serious disabling, often depriving the patients' independence. Because of this such injuries account for a sizeable proportion of admissions to orthopaedic and urological beds. Therefore the rapid and correct imaging modalities are useful to establish a right diagnosis of the pelvic trauma and more specifically the type of pelvic fracture and associated soft tissue injuries.

The primary aim of the study was to establish the base line data of the pattern of the pelvic trauma, associated soft tissue injuries and the appropriate imaging modalities used to achieve diagnosis, since there is no current available data in our set up. Advanced imaging modalities like CT Scan and ultrasound were introduced in Nairobi in 1991. Since then it has not been shown if there is increased diagnostic accuracy of pelvic fractures and the possible associated soft tissue injury as compare to conventional radiography. The long term goal include sustaining follow up of patients with pelvic trauma by using the available modern imaging modalities as the continuous audit, with aim of improving post – traumatic care of the patient with pelvic injuries.

RESEARCH OBJECTIVES

Broad objective:

To find the pattern of pelvic trauma and possible associated soft tissue injury as shown by various imaging modalities in Nairobi - Kenya.

Specific objectives:

1) To determine the most common types of pelvic fractures in Nairobi - Kenya.

2) To determine the pattern of soft tissue injuries in patient with pelvic trauma in Nairobi - Kenya and whether the soft tissue injuries correlated to pelvic fracture classification.

3) To determine the types of imaging modalities used in the management of patients with pelvis injury in Nairobi – Kenya

Expected benefits

- The results from the study are expected to add knowledge to the existing information on the pelvic injury, associated soft tissue injury, and relevant imaging technique.

- To establish baseline data and the extent of the problem.

BACKGROUND INFORMATION AND ANATOMY REVIEW.

The pelvis is the region of the trunk that lies below the abdomen. The term pelvis is loosely used to describe the region where the trunk and lower limbs meet. The word pelvis means a basin describing the skeletal pelvic girdle or bony pelvis (4).

Normal Anatomy and embryology of the pelvis

The pelvis is a ring-like structure comprising three principal bones; the paired innomimate bones and sacrum. The innominate bones are joined anteriorly at the pubic symphysis, and the sacrum is joined to the innominate bones at the sacroiliac joints. The sacroiliac joints and pubic Symphysis are relatively immobile.

Embryologically the human pelvic girdle follows the general growth and development evolved in land vertebrates, and is less modified than the scapula. Three main centers of ossification appear and gradually shape into the primitively dorsal ilium, cranioventral pubis and ventrocaudal ischium. Where the three-element join there is a cup-shaped depression, the acetabulum, forming the socket for the head of the femur. The two pubic bones unite in the symphysis pubis along their midventral lengths, while the two ilia articulate with the sacrum posteriorly (5). Therefore innominate bone represents the fusion of three separate centers of ossification or developmental bones; the ilium, ischium and pubis (figure 1).

The pelvis may be divided into two arches by a transverse plane passing through the acetabular cavities (figure 2); the posterior arch is chiefly concerned in transmitting weight of the trunk. Its essential parts are the upper three sacral vertebrae and two strong pillars of the ilium bone running

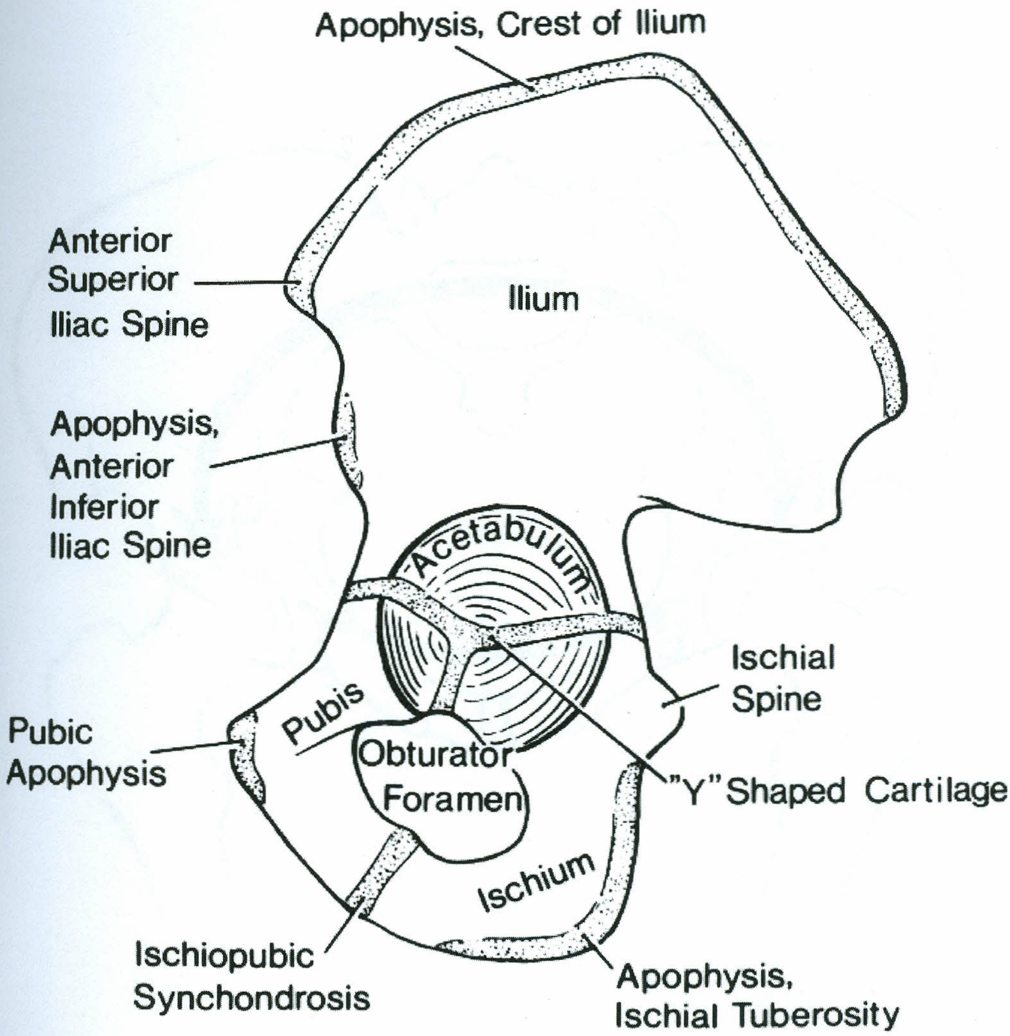


Fig 1: Ossification centers of the pelvis

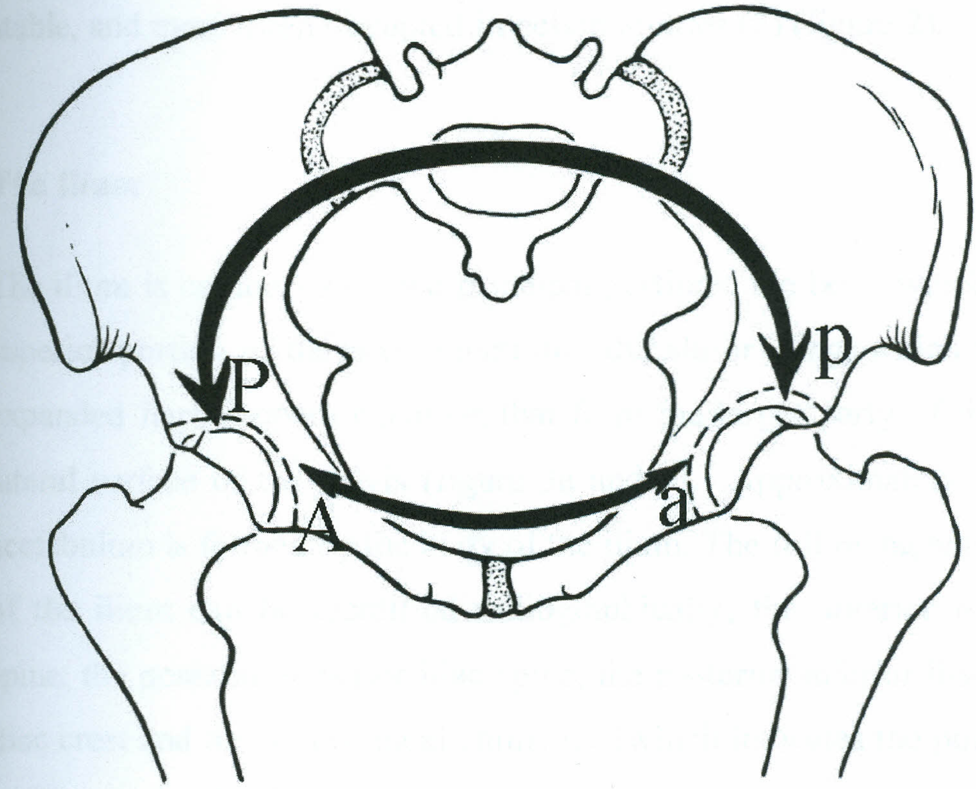


Fig 2: Anterior (Aa) and Posterior (Pp) arches of the pelvis

from the sacroiliac joints to the acetabular fossae; it is very strong and more stable. The anterior arch is formed by the pubic bones and their superior rami. It connects the bases of the lateral pillars of the posterior arch and so acts as a tie beam completing the ring, anteriorly. The anterior strut resists the medial thrust of the femoral head. The anterior arch is weaker and less stable, and more often disrupted in pelvic injuries (2) (figure 2).

The Ilium

The ilium is composed of two principal portions, the body which forms the superior portion of the acetabulum and the ala or wing, which is the large expanded flared superior portion that form the larger party of the posterior lateral surface of the pelvis (figure 3a and b). Approximately 40% of the acetabulum is formed by the body of the ilium. The following anatomic parts of the ilium can be identified radiographically; the anterior inferior iliac spine, the posterior superior iliac spine, the posterior inferior iliac spine, the iliac crest and the iliopectineal eminence (which indicates the point of union of ilium and pubic), the iliac fossa, the articular surface for articulation with the sacrum; and tuberosity of ilium (figure 3a and b).

The Ischium

The ischium is made up of the body and descending inferior ramus. The body of the ischium form approximately 40% of the acetabulum, the portion located posteriorly and anteriorly. The ischial spine is a triangular eminence arising from the dorsal and medial surfaces of the body of the Ischium. The

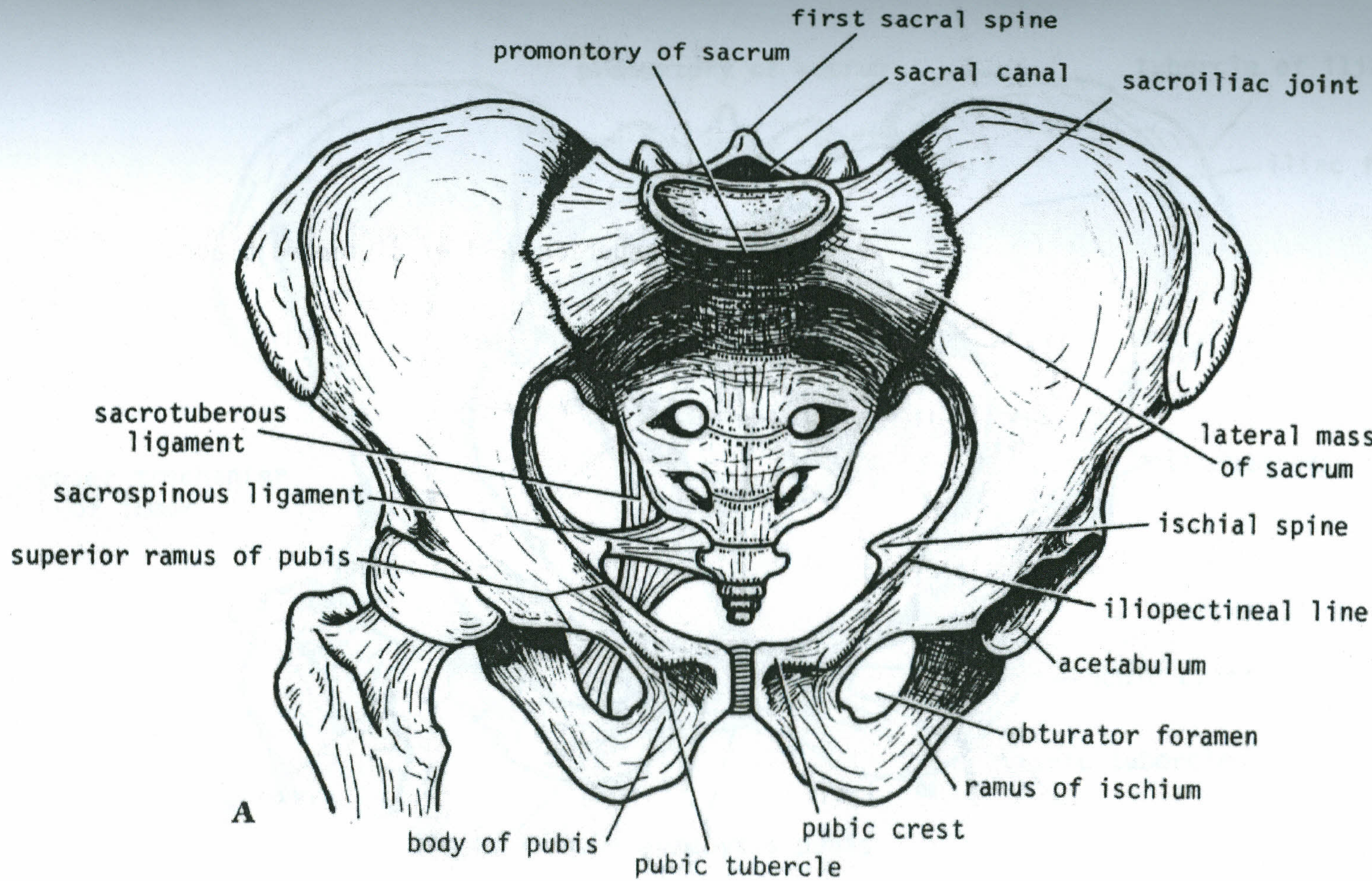


Fig 3a: Male Pelvis as seen on Anterior View.

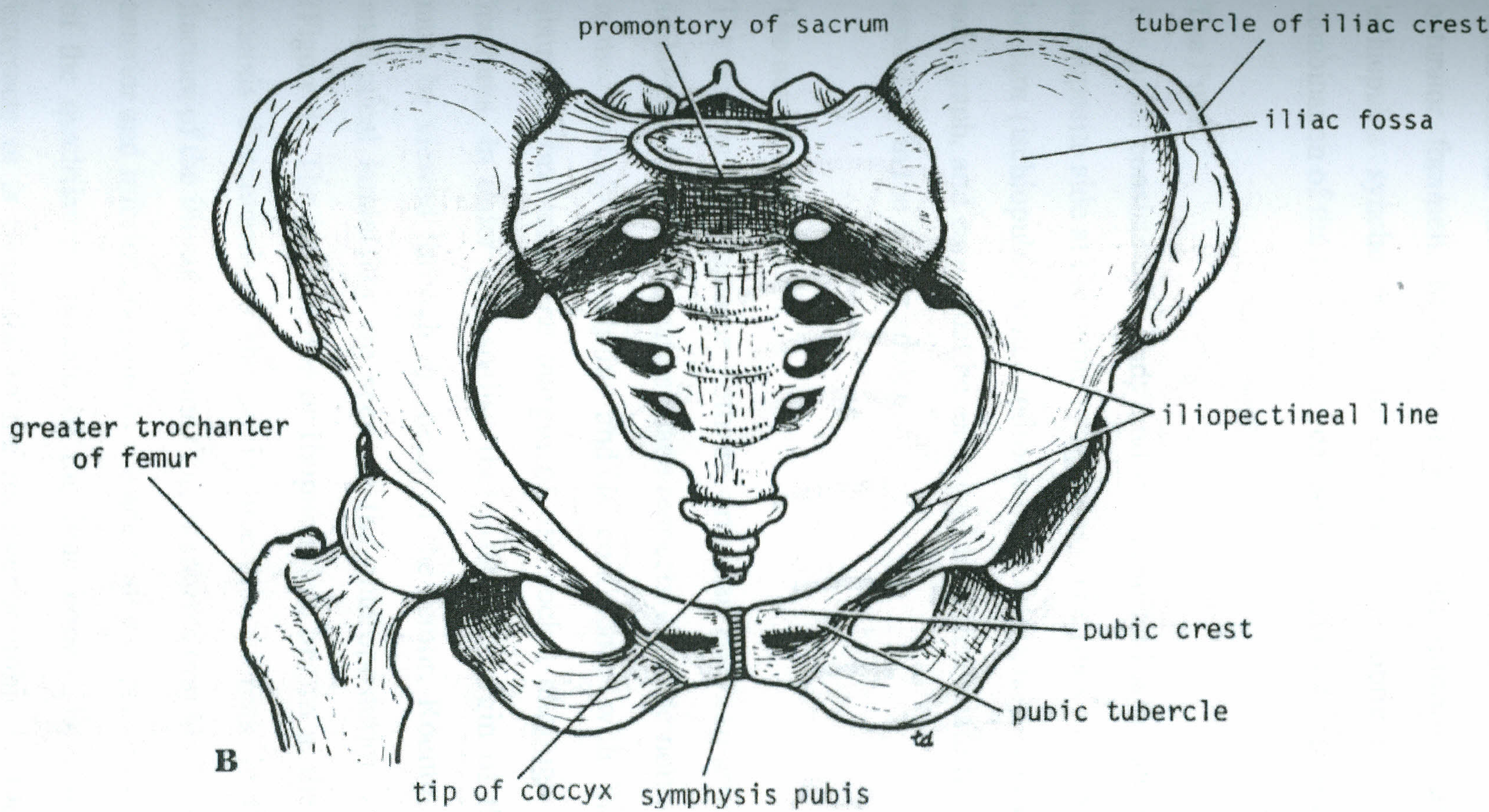


Fig 3b: Female Pelvis as seen on anterior view.

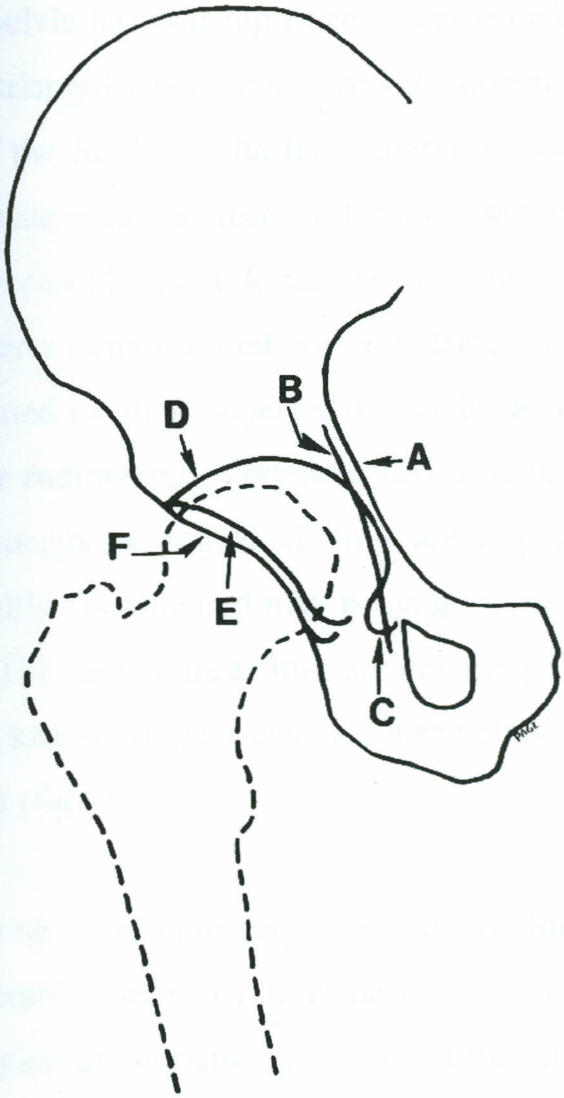
ramus extends inferiorly and medially to form the inferior border of the obturator foramen. Medially it joins with inferior pubic ramus at the ischiopubic synchondrosis to complete the obturator foramen and the combination of the two rami, is called the ischiopubic ramus (6).

The Pubis

The pubis consists of a body and two rami and is united with its fellow of the opposite side at the pubic symphysis. The lines of union of the pubis and ischium (ischiopubic synchondrosis) are frequently readily evident on the radiograph, and care must be exercised to differentiate these from fractures, especially in the young adults.

The acetabulum

The acetabulum contains both an articular and non-articular portion, the acetabular fossa and lunate surface respectively. The non-articular portion is formed mainly by ischium and is continuous with the margin of the obturator foramen. The margin of this socket although thick is prone to fractures. In order to visualise the posterior margin of the acetabulum, it must be viewed through the head of the femur. Roentgenographically six anatomical landmarks are seen on the anteroposterior view of the pelvis (Figure 4). The arcuate line or Iliopubic line begins at the sciatic notch and extends downwards to the pubic tubercle; a break in this line indicates fracture of the iliopubic column. The roentgenographic U is composed of the anterior and inferior portions of the acetabular fossa and the adjacent margin of the quadrilateral surface of the iliac bone. The ilioischial line either intersects or is tangential to the roentgenographic U. Other landmarks of interest are roof, the anterior and posterior lips of the acetabular.



A. Arcuate or iliopubic line
B. Ilioischial line
C. Roentgenographical U
D. Acetabular roof
E. Anterior lip of the acetabulum
F. Posterior lip of the acetabulum

Fig 4: Graphic design demonstrates detail landmarks of the acetabular anatomy.

The sacrum and coccyx

In addition the pelvis has two hip bones together with sacrum and coccyx. The sacrum is a triangular bone that forms the dorsal part of the pelvis. The body consists of the fusion of the five embryonic vertebral segments. The lateral mass of those segments fuses to form the sacral alae or wings. Within the alae are the paired sacral foramina. The first two or three of these foramina are clearly demonstrated on the anteroposterior view of the pelvis and sharply defined on their superior border by a fine line. The coccyx is made up of four rudimentary vertebrae and articulates superiorly with the sacrum. The coccyx is angled slightly anterior to the sacrum, but the angulation is highly variable and may be as great as 90% and still be within normal limits. The iliopectineal line divides the pelvis into two areas; the one above being known as the greater or false pelvis and the other one below as the true pelvis (fig 5).

The pelvic bony structures are very firmly bound together; and it ordinarily requires considerable force to injure the bony cage. The most vulnerable portion is the region of the pubis rami, part of the anterior arch, as described above. An injury in this location will frequently be accompanied by "countercoup" fracture of the opposite wing of the sacrum, or sublaxation of the opposite sacroiliac joint.

The female bony pelvis is of particular importance because of its obstetric functions. The true pelvis has an inlet, a cavity and outlet. The pelvic inlet with its variations can be classified into four types, depending on the inlet shapes; anthropoid, gynecoid, android, and platypelloid pelvic.

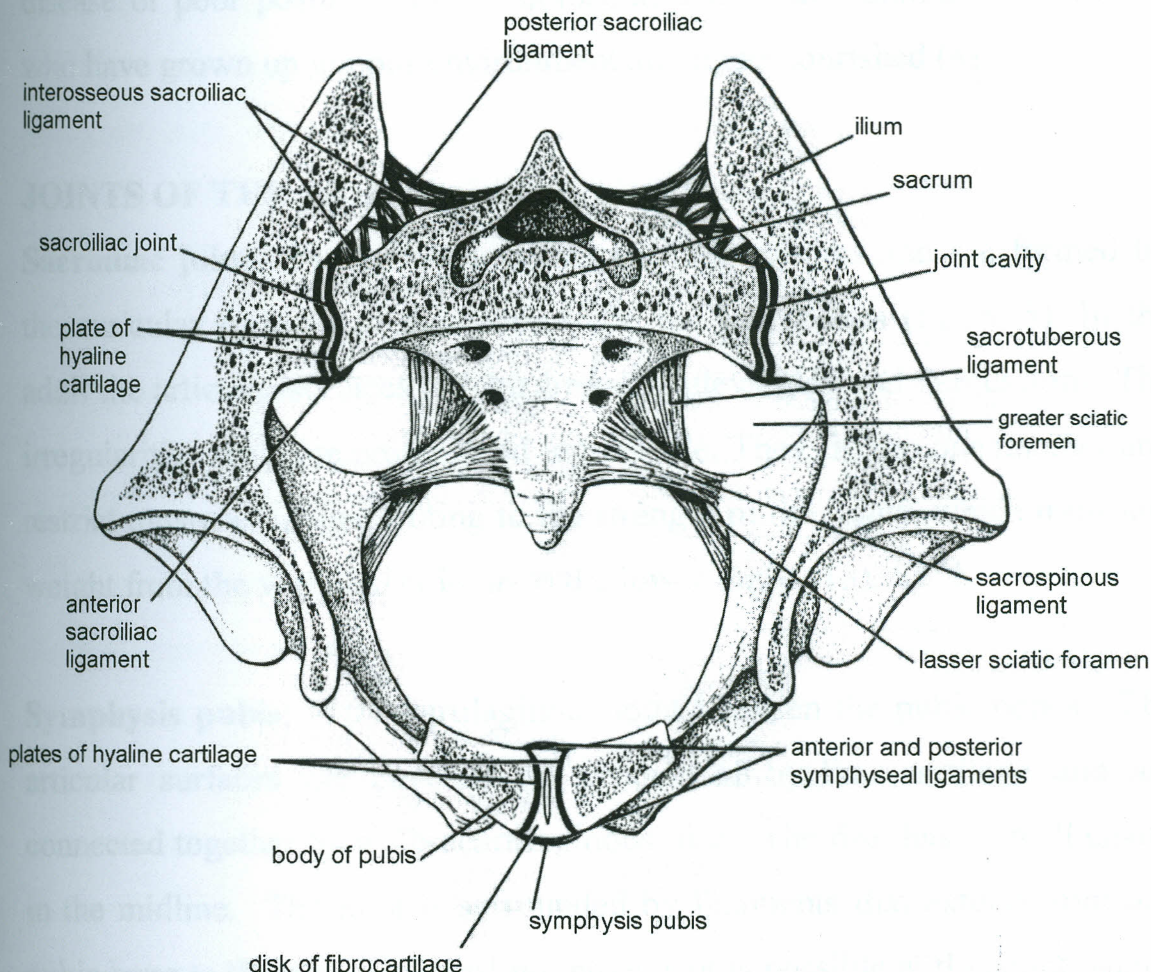


Fig 5: Horizontal section of the pelvis showing the sacroiliac joints and symphysis pubis.

Deformities of the pelvis in the female may be responsible for dystocia. A contracted pelvis may obstruct the normal passage of the foetus. The cause of pelvic deformities may be congenital (rare) or acquired, from fractures, disease or poor posture. Pelvic deformities are more common in women who have grown up in poor environment and undernourished (4).

JOINTS OF THE PELVIS

Sacroiliac joints; the sacroiliac joints are strong joints and are formed by the auricular surfaces of the sacrum and the iliac bones (figure 5). In the adult the articular surfaces exhibit irregular elevations and depressions. The irregularities are more pronounced in the male. They fit into one another and restrict movement, contributing to the strength of the joints, which transmits weight from the vertebral column to the lower limbs (13).

Symphysis pubis; is the cartilaginous joint between the pubic bones. The articular surfaces are covered by a layer of hyaline cartilage and are connected together by a fibrocartilaginous disc. The disc has a small cavity in the midline. The joint is surrounded by ligaments that extend from one pubic bone to the other. Almost no movement is possible at this joint. Acute disruption of the pubic symphysis is caused by high impact injuries. Damages to the urinary structures occur in 10% of pubic symphysis injury (7).

Sacrococcygeal joint; is a cartilaginous joint between the bodies of the last sacral vertebral and the first coccygeal vertebral. The cornua of the sacrum and coccyx are joined by ligaments. A great deal of movements is possible at this joint, a feature of great value in parturation.

Stability of the pelvis

The remarkable feature of the pelvis in vivo is its stability (8). This stability is conferred by the continuous osseous-ligamentous ring and is principally due to the strength of several groups of ligaments and the broad sacroiliac articular surfaces. The strongest ligaments are placed posteriorly making the posterior arch very strong and stable. Conventionally, the sacrum is described as being posterior, but due to the inclination of the pelvis at an angle, the sacrum is superior in relation to the symphysis pubis.

Ligaments; The principal ligaments are shown diagrammatically in figure 6a and 6b. The anterior sacro-iliac ligaments consist of transverse and oblique fibres running in flat bands. They resist external rotation and shear forces across sacro-iliac joints. The interosseous sacro-iliac ligaments unite the tuberosities of ilium and sacrum. Together with posterior sacro-iliac ligaments and the iliolumbar ligaments, running between the L5 transverse process and iliac crest, they form a posterior complex analogous to a suspension bridge.

The posterior superior iliac spines represent the pillars, the sacrum represents the bridge and the interosseous ligaments represent the suspension bars. This prevents anterior/inferior displacement and rotation of the sacrum together with the axial skeleton on weight bearing, but it allows some rotation at the sacro-iliac joint during movement. This accounts for the stability of the superior part of the posterior pelvic ring.

Inferiorly, the sacro-spinous ligaments resist external rotation. The sacro-tuberous ligaments placed at right angles to the sacro-spinous ligaments,

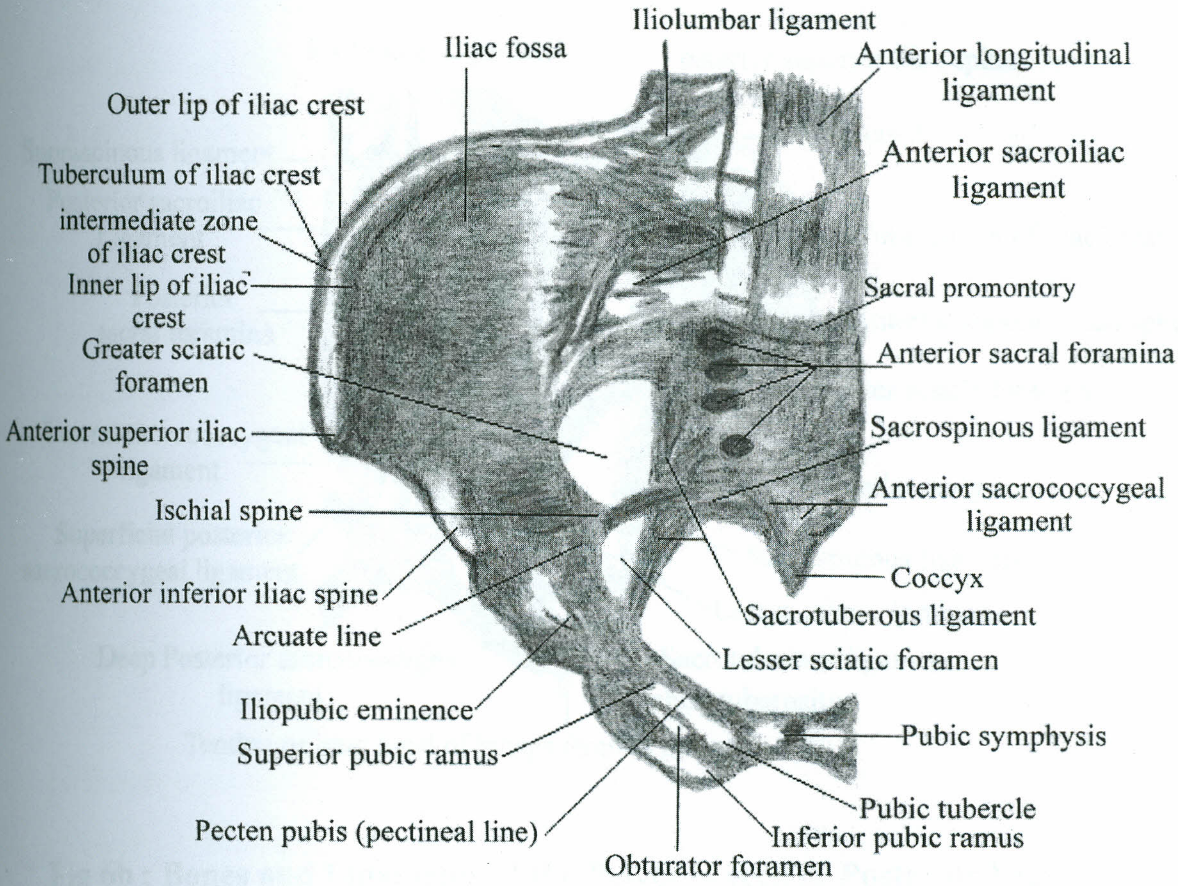


Fig 6a: Bones and Ligaments of the Pelvis as seen in anterior View

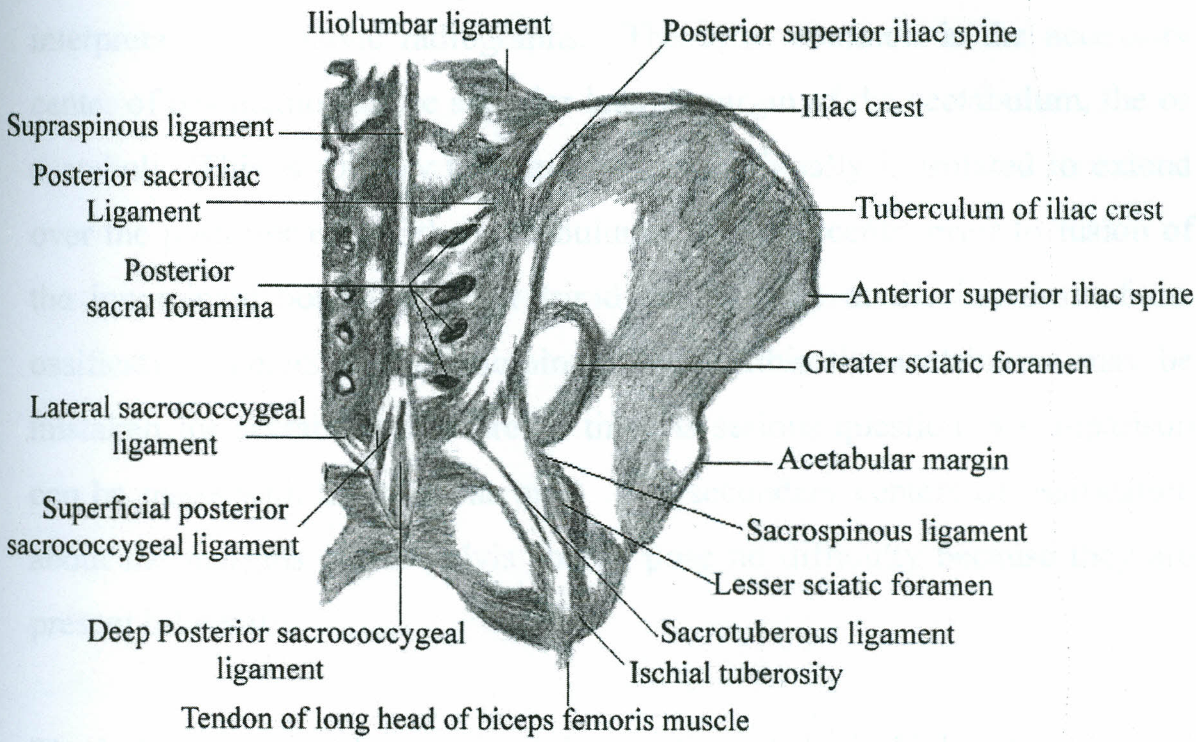


Fig 6b : Bones and Ligaments of the Pelvis as seen in Posterior View

further resist rotational forces and also resist shearing forces contributing to the stability of the posterior pelvic arch.

Normal variants of the pelvis:

There are a few normal variants which should pose no significant difficult in interpretation of pelvic radiographs. The most common is the accessory center of ossification at the superior lateral margin of the acetabulum, the os acetabuli. This is roughly triangular and occasionally is isolated to extend over the posterior rim of the acetabulum. In adolescents, prior to fusion of the innominate bone, the Y or triradiate cartilage at the junction of the ossification centers of the innominate bone within the acetabulum may be mistaken for acetabular fracture. If there is serious question, a comparison can be made with the opposite side. The secondary centers of ossification about the margins of the pelvis should pose no difficulty because they are present bilaterally.

The ischiopubic synchondrosis at the junction of the ischial and pubic rami located at the inferior medial aspect of the obturator foramen may be bulbous since the opposing margins of rami tend to flare. The synchondrosis is most prominent before the age of 10 years and is usually fused by 12 or 13 years. While it is unlikely that this would be mistaken for a fracture, neither should it be mistaken for tumour, infection or healing fracture. The appearance is usually similar on the opposite side, although at times the synchondroses are asymmetric. `

The posterior acetabular lip may arise from a secondary ossification center. This may cause a problem in adults, where dislocation and fracture dislocation of the hip are relatively common and an ununited posterior lip apophysis may be very difficult to distinguish from a fracture of the acetabulum. The distinction is usually made on the location and size of the ossicle, the cicumferential sclerosis (cortication) of its margins, and the fact that non-union of the apophysis is usually bilateral.

CONTENTS OF PELVIC CAVITY

Pelvic viscera in male;

The Rectum, sigmoid colon and terminal coils of ileum occupy the posterior part of the pelvic cavity in both sexes (figure 7 and 8). The contents of the anterior part of the pelvic cavity in male are urinary bladder in which is situated immediately behind the pubic bone. Ureters cross the pubic inlet in front of the bifurcation of the common iliac artery. The ureters run downward and backward in front of internal iliac artery to reach the region of ischial spine and then enter the upper lateral angle of the bladder, both sides. Others include vas deferens, seminal vesicles, prostate, prostatic urethra, visceral pelvic fascia and peritoneum (figure 7).

Pelvic viscera in female; the rectum colon, and terminal coils of ileum occupy the posterior part of the pelvic cavity as in males. The content of anterior pelvic cavity in the female are urinary bladder which is situated immediately behind the pubic bones, the ureters, ovaries, follopian tubes, uterus, vagina, visceral pelvic fascia and peritoneum (figure 8).

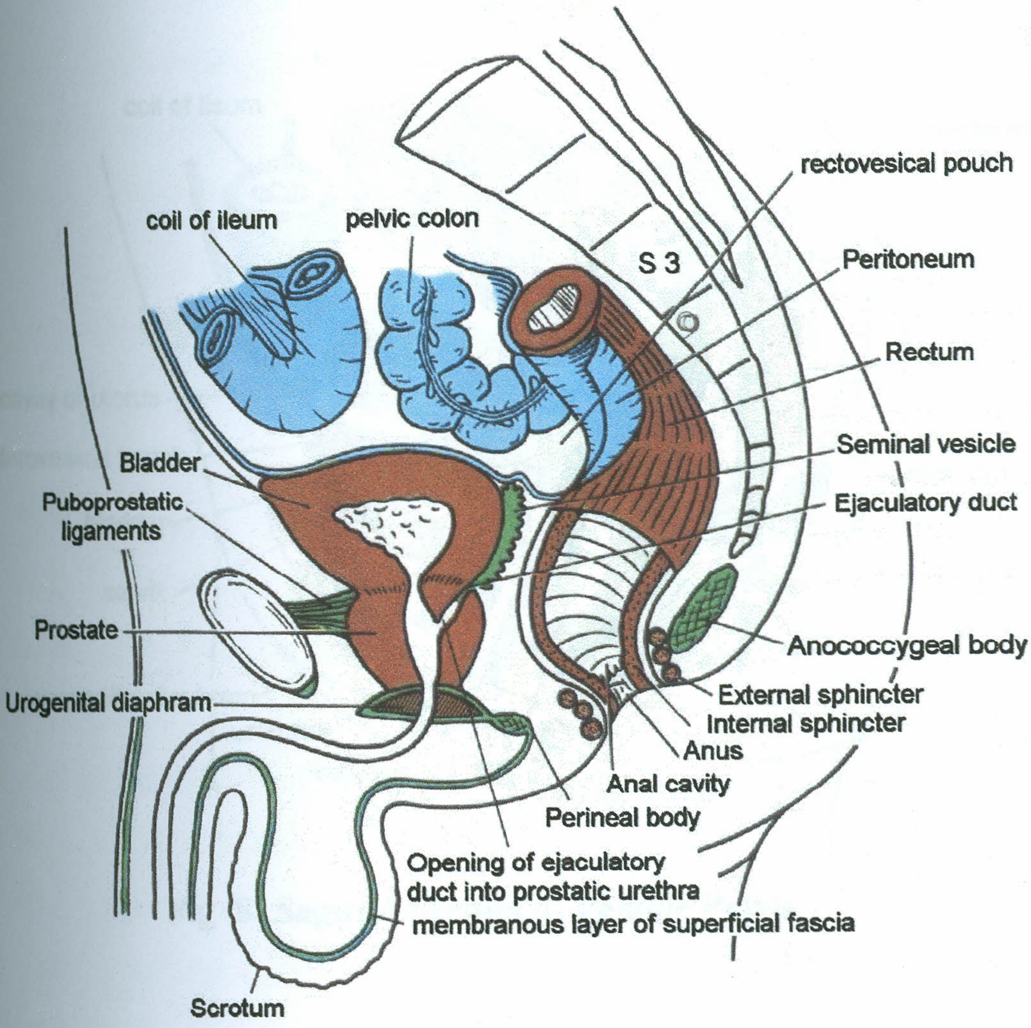


Fig 7: Sagittal Section of Male Pelvis

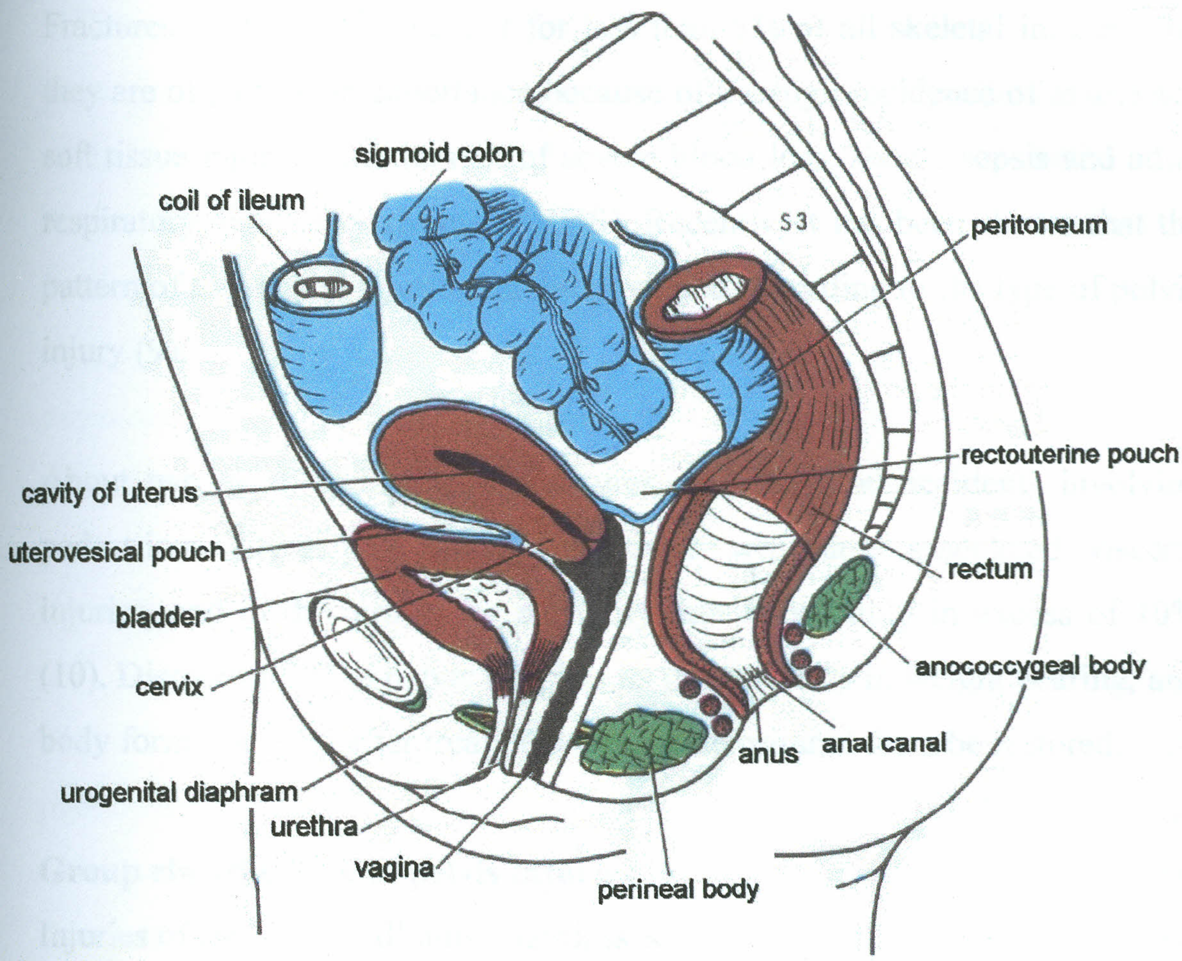


Fig 8: Sagittal Section of Female Pelvis

STATEMENT OF THE PROBLEM AND REVIEW OF LITERATURE

1. Pelvic injuries

Fractures of the pelvis account for less than 5% of all skeletal injuries, but they are of particular importance because of the high incidence of associated soft tissue injuries and the risk of severe blood loss, shock, sepsis and adult respiratory distress syndrome (ARDS). Recently, it has been shown that the pattern of associated injuries can be predicted according to the type of pelvic injury (9).

About two third, of all pelvic fractures occur in road accidents involving pedestrians. Over 10% of these patients will have associated visceral injuries, and in this group the mortality rate is probably in excess of 10% (10). Disruption of the pelvic ring has its gross effects in weight bearing, and body form, for even after treatment would the original form be restored.

Group classification of pelvis injuries

Injuries of the pelvis fall into four classes.

i) Isolated fractures with an intact pelvic ring.

ii) Fractures with a broken ring – these may be stable or unstable.

iii) Fractures of the acetabulum.

iv) Sacrococcygeal fractures.

(I) ISOLATED FRACTURES WITH AN INTACT PELVIC RING

(a) Avulsion fracture

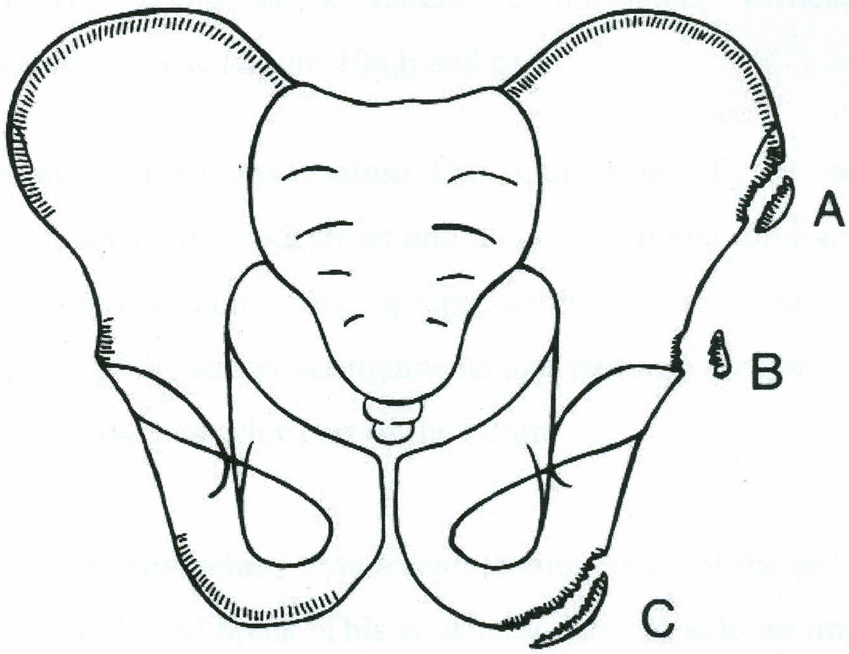
A piece of bone is pulled off by violent muscle contraction; this is usually seen in sportsmen and athletes (11). The sartorius may pull off the anterior superior iliac spine, the rectus femoris the anterior inferior iliac spine, the adductor longus a piece of the pubic and the hamstrings part of the ischium. These injuries cause abrupt onset of a sharp stabbing pain and tenderness. Radiographs are positive 2 -3 weeks after fracture, but if too long a period elapse before they are carried out, the frequent exuberant callus may suggest osteosarcoma. Treatment of such fracture is by simple bed rest until the patient is then allowed to ambulate (12) (figure 9).

(b) Fatigue or Stress fractures

These fractures result as a consequence of repeated stress. Fractures of the pubic rami are fairly common (and often quite painless) in severely osteoporotic or osteomalacic patients. Obscure stress fractures are best demonstrated by radioisotope scans. These fractures are most frequently seen in jogger and the long distance marathon runner and military recruits. They generally occur in the pubic rami where it joins the ischial near the symphysis and comprise only 1.25% of the stress fractures in endurance runners (12).

(c) Direct fractures

A direct blow to the pelvis, usually after a fall from height, may fracture the ischium or the iliac blade. Bed rest until pain subsides is usually all that is needed.



A. Anterior Superior Iliac Spine
B. Anterior Inferior Iliac Spine
C. Ischial Tuberosity

Fig 9: Apophyseal Avulsion of the Pelvis

(II) FRACTURES WITH A BROKEN RING

(a) Mechanism of Injury

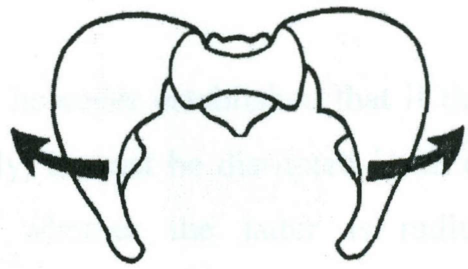
Tile and Pennale were the first to suggest a classification based on the forces producing the injury (13). The basic mechanisms of pelvic ring injuries are anteroposterior compression, Lateral compression, vertical shear and combinations of these (figure 10a,b and c).

- **Anteroposterior compression;** This injury is usually caused by a frontal collision between a pedestrian and a car. The pubic rami are fractured or the innominate bones are sprung apart and externally rotated with disruption of the sacroiliac ligaments and partially torn, or there may be a fracture of the posterior part of the ileum.

- **Lateral Compression;** Side to side compression of the pelvis causes the ring to buckle and break. This is usually due to a side-on impact in a road accident or a fall from height. Anteriorly the pubic rami on one or both sides are fractured and posteriorly there is a severe sacroiliac strain or a fracture of ileum, either on the same side as the fractured pubic rami or on the opposite of the pelvis; these are usually unstable pelvis fractures.

- **Vertical Shear;** The innominate bone on one side is displaced vertically, fracturing the pubic rami and disrupting the sacroiliac region on the same side. This occurs typically when someone falls from height onto one leg. Vertical shear injuries are usually severe and unstable with gross tearing of the soft tissues and retroperitoneal haemorrhage.

- **Combination injuries;** In Severe pelvic injuries there may be a combination of the above



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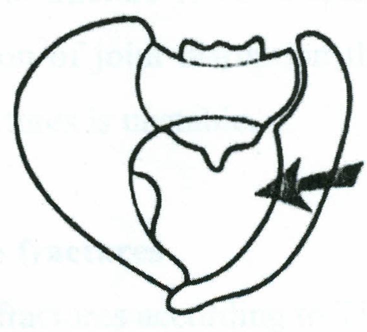
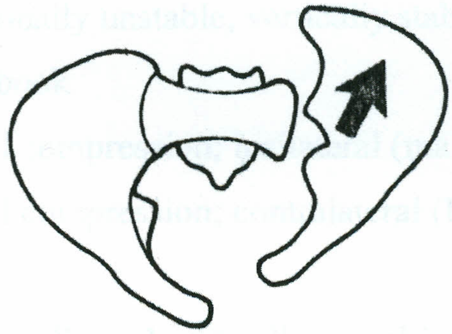


(b)



(c)

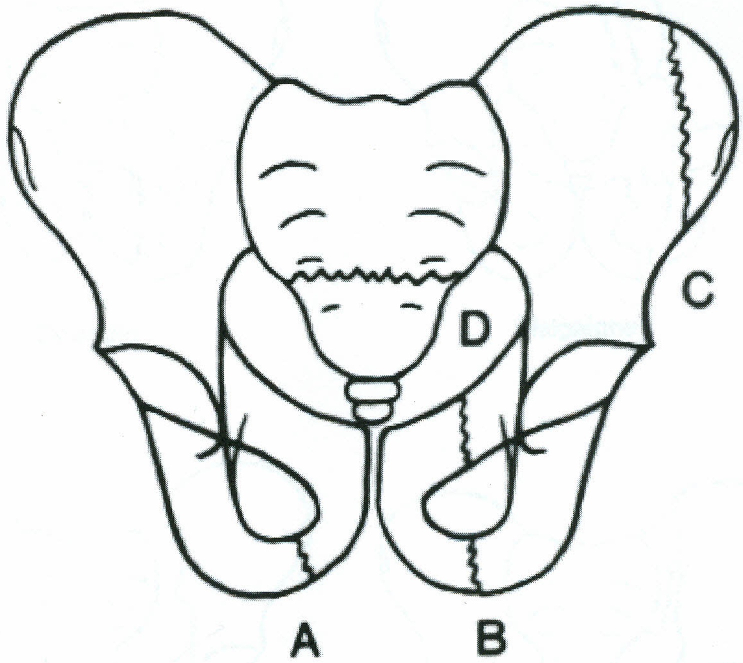
Fig 10:(a), (b) and (c) Illustrates main pattern of injury with a force vector.

Recent studies have however established that if the pelvic ring is disrupted in one side anteriorly, it must be disrupted in an opposite posterior side as well regardless of whether the latter is radiographilcally discernible. Exceptions are fractures due to direct blows (including fractures of the acetabular floor), or ring fracture in children, whose symphysis and sacroiliac joints are springy. Often however, the second break is not visible either because the sacroiliac joints are only partially disrupted. In these circumstances, the visible fracture is not displaced and the ring is stable.A fracture with combination of joint disruption that is markedly displaced or obvious double ring fractures is unstable.

(b) Stable and unstable fractures

Classification of pelvic fractures according to Tile and Pennale et al (1988)

Type	A	Stable
	A1	Fracture of the pelvis not involving the ring
	A2	Stable, minimally displaced fractures of the ring.
Type	B	Rotationally unstable, vertically stable
	B1	Open book
	B2	Lateral compression; ipsilateral (malgaignes)
	B3	Lateral compression; contralateral (Bucket handle)
Type	C	Rotationally and vertically unstable
	C1	Unilateral
	C2	Bilateral (straddle)
	C3	Associated with an acetabular fracture.



A. Single Pubic Ramus
B. Unilateral Pubic Ramus
C. Iliac (Duverney)
D. Sacrum or Coccyx

Fig 11: Stable; Single break in pelvic ring

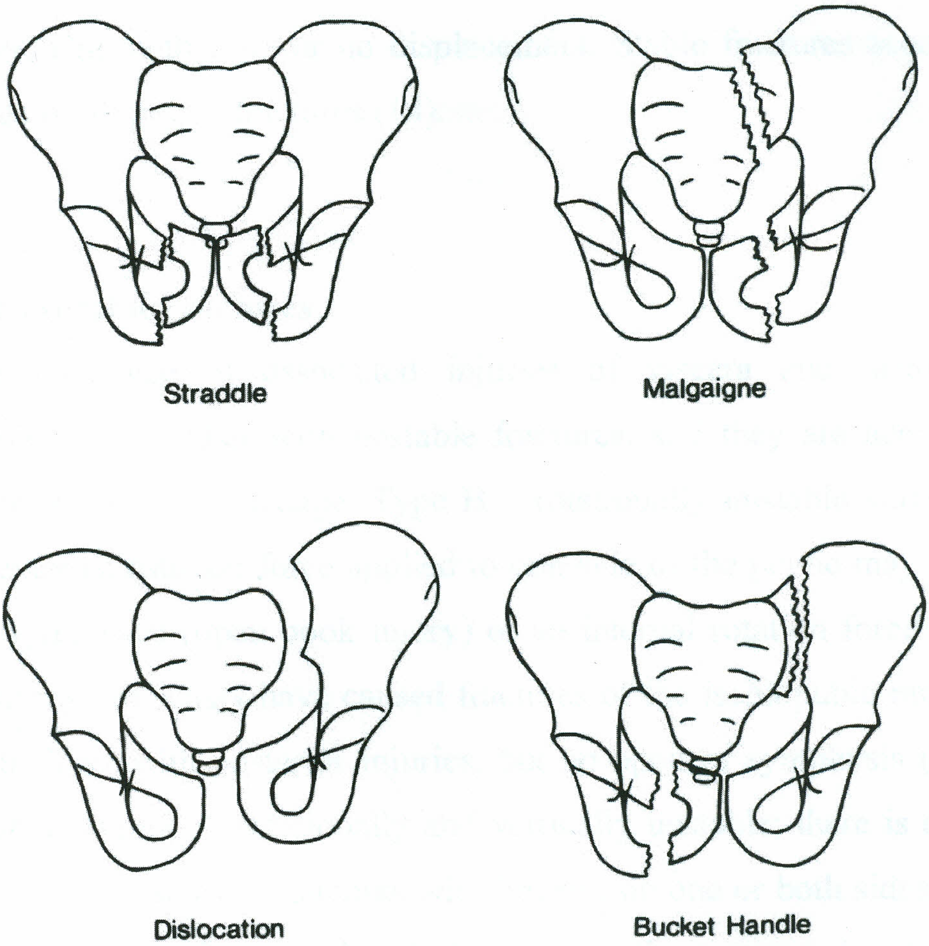


Fig 12: Unstable; double breaks in pelvic ring

Stable fractures

Generally stable fractures consists of single breaks in the pelvic ring or fractures of the peripheral margin which do not disrupt the pelvic ring in two or more places. In Type A - stable; this includes avulsions and fracture of the pelvic ring with little or no displacement. Stable fractures account for two thirds of all pelvic fractures (14).

The unstable fractures

The incidence of associated injuries of viscera and urinary tract is considerably higher with unstable fractures, and they are accompanied by more severe haemorrhage. Type B – rotationally unstable vertically stable, an external rotation force applied to one side of the pelvic may sprung open the symphysis (open book injury) or an internal rotation force – i.e. lateral compression – may have caused fractures of the ischiopubic rami on one or both sides, with posterior injuries, but no open of symphysis (closed book injury). Type C – rotationally and vertically unstable; there is disruption of the strong posterior ligaments with injuries on one or both sides and vertical displacement of one side of the pelvis; there may also be acetabular fractures.

(III) FRACTURE OF THE ACETABULUM

Fractures of the acetabulum occur when the head of the femur is driven into the pelvis. This is caused either by a blow on the side (as in a fall from height) or by a blow on the front of the knee usually in a dash board injury driving the femur posteriorly against the acetabular. The femur may also be fractured.

Classification - Judet and Letournel – 1981 (10)

1. Anterior acetabulum column (the iliac wing and pubic segment of the pelvis) fracture; the fracture runs through the thin anterior part of the acetabulum separating a segment between the anterior inferior iliac spine and the obturator foramen. It does not involve the weight bearing area and has good prognosis.

2. Posterior acetabulum column (the posterior half of the acetabular floor, margin and roof) fracture; The fracture runs upwards from the obturator foramen into the sciatic notch, separating the posterior ischiopubic column of the bone and breaking the weight – bearing part of the acetabulum. It is usually associated with a posterior dislocation of the hip and may injure the sciatic nerve.

3. Central acetabulum fracture; Are those in which the fracture involves primarily the concavity of the acetabulum fossa with the femoral head protruding into the pelvis. These fractures are classified as type I, II, and III depending upon whether there is minimal, moderate or complete protrusion. Each type can further be subdivided by the absence or presence of an associated superior pubic ramus fracture.

4. Complex fracture; most acetabular fractures are complex injuries which damage either the anterior or posterior segment or both as well as the roof of the walls of the acetabulum.

(iv) Sacrococcygeal

A blow from behind or a fall onto the 'tail' may fracture the sacrum or coccyx, or sprain the joint between them. Women are affected more commonly than men (10). Plain radiography may show (i) a transverse fracture of the sacrum, in rare cases with the lower fragment pushed forwards, (ii) a fractured coccyx, sometimes with the lower fragment angulated forward or (iii) a normal appearance if injury, was sprain of the coccygeal joint.

SOFT TISSUE INJURIES

2. At 'risk' structures

Within the pelvis there are several at 'risk' structures that are in danger when a major disruption occurs. These structures can be grouped together as follows;

- Pelvic viscera (bladder and urethra, vagina and rectum).
- Neurological (Lumbo-sacral plexus, especially L5 nerveroot, coccygeal plexus)
- Vascular (internal iliac vessels, external iliac vessels)

The pelvic colon, with its mesentery is a mobile structure and therefore not readily injured. However the rectum and anal canal are more firmly tethered to urogenital structures and the muscular floor of the pelvis and therefore vulnerable in pelvic injuries.

The lower urinary tract system

The lower genital urinary system comprises of the urinary bladder, urethra and external genitalia. Bladder injuries mostly occur in blunt trauma; 85%

occur with pelvic fracture and 15% with penetrating trauma and blunt mechanisms without pelvic fracture (full bladder blow out) (16). Urethra injury is predominantly a male condition.

1. URETHRA

Fracture of pelvis with tear of the urethra

Anatomically the male urethra has always been considered to be divided into two parts: (i) the posterior urethra, which includes the prostatic and membranous portion and (ii) the anterior urethra, which extends from the uroginetial diaphragm to the urethral meatus. The membranous urethra is the section surrounded by the external sphincter muscles; it begins immediately distal to the apex of the prostate gland (verumontanum) and lies between the two layers of the triangular ligament (urogenital diaphragm).

Although it has been said in many articles that injury to the female urethra is rare, M.O Petty et al report a 4.6% incidence (six of 130 female patients) of urethral injuries coexistent with pelvic fractures. The presence of blood in the vaginal introitus should lead to meticulous cystoscopic and radiographic evaluation in the female patients with voiding difficulties or vulva oedema after trauma (39)

Classification of urethral injuries

Blunt trauma is responsible for 60% of urethral injuries commonly occurring in association with pelvic fractures. Forty percent of urethral injuries can also occur with the injuries to the peritoneum, gunshots, stab wounds or from instrumentation (17). Injuries to the proximal urethra are mostly secondary to the pelvic fractures, while injuries to the distal urethra is most commonly due to penetrating (self – inflicted) injuries (18). Traumatic urethral injuries are classified in to three different types both clinically and radiologically.

Clinical classification

Type I Incomplete; urethra intact but contused, thus the catheter can be passed.

Type II Partial; there is a hole in the urethra –using precatheter urethrography can show this, and usually urine leaks during micturation.

Type III- complete separation.

Radiological classification

Type I Incomplete; urethrography shows intact urethra, it is either compressed or contused.

Type II Partial or complete tears present above the urogenital diaphragm, at urethography contrast is seen in the pelvic cavity.

Type III Partial or complete rupture below the urogenital diaphragm contrast is seen in perineum or scrotum. This type is the commonest of the three.

2.URINARY BLADDER

Classification of bladder injuries.

Bladder injuries are classified as intraperitoneal and extraperitoneal. Main causes of bladder injuries include motor vehicle accidents (MVA), motorcycle accidents (MCA), bicycle accidents and gunshot.

Extraperitoneal Injury of the bladder

The bladder wall may be damaged out side the peritoneum along with the damage to the urethra and other viscera in fracture of the pelvis where the bladder is lacerated by a spike of bone (19). Other extraperitoneal perforations of the bladder may be caused by gunshot, and other sharp instrument like knife (20). Extraperitoneal bladder injuries account for 65-85% of bladder injuries and are associated with pelvic fracture in 95%.

Intraperitoneal injury of the bladder

Usually these occur with full-distended bladder. The bladder busts into peritoneal cavity. Intraperitoneal injuries account for 15-35% of bladder injuries and infrequently are associated with pelvic fracture (16). Gross haematuria, pelvic fluid and fractures are highly correlated with bladder rupture; identification of these findings may help in the selection of trauma patients for Computerised Tomography.

3. NEUROLOGICAL INJURIES

In Losser series of 100 patients with pelvic fractures, 5% patients, all with severe vertical shear fractures were found to have neurologic injuries. The most commonly injured nerve was the sciatic nerve. He found that this occurs mainly at three anatomical location (10).

(i) Fracture ilium with narrowing of greater sciatic foramen

(ii) Fracture dislocation of the hip with impingement of the nerve.

(iii) Fracture ischium with displacement and consequent injury to the nerve.

Fortunately, neurologic damage is rarely permanent because the injury is one of contusion or stretch rather than transection. Lumbosacral plexus injury can also occur with a clear predominance of neurological signs attributed to L5 nerve and L5/S1 levels. The diagnosis of neurological injuries is frequently overlooked initially. The diagnosis is made later when the patient returns with complain of muscle weakness and atrophy of calf muscles and hamstrings are identified.

4. VASCULAR INJURIES

In patient with total disruption of the sacroiliac joint there is a high incidence of bleeding from the pelvic vessels, usually the superior gluteal, Internal iliac, pudendal, obturator and inferior epigastric arteries but an almost zero incidence of injury to the liver or spleen (21). This information is useful in directing the angiographer to the likely site of haemorrhage, during arteriogram. Venous bleeding usually stops itself after immobilisation (22).

IMAGING STUDIES AND RADIOGRAPHIC INTERPRETETION

Radiography (x-rays) is the main modality in trauma imaging, and with good reason; most traumatic lesions of the skeleton can be documented effectively utilizing standard radiographs (23). The location and nature of a fracture are usually well demonstrated on the radiographs, but the status of the adjacent soft tissues is usually very difficult to assess.

1. Plain radiographic film Interpretation

An anteroposterior radiograph should be systematically examined. In the first instance, this view will identify all significant major pelvic disruptions, and in clinical practice, time should not be spent taking further serial radiographs if this delays resuscitation of the patient. The lower lumbar vertebrae followed by sacroiliac joints, the different parts of the innominate bones, and finally the hip joints and upper ends of the femurs are examined (figure 13). Gas and fecal material may be seen in the large bowel, and soft tissue shadows of the skin and subcutaneous tissues may also be visualized. To demonstrate the sacrum and sacroiliac joints more clearly, lateral and oblique views of the pelvis are often taken. The importance of classification system is lost if the correct diagnosis is missed initial, during interpretation of the plain pelvis radiography. Correct radiographic assessment is therefore essential in the early stages following injury.

Plain radiography usually comprises an anteroposterior view, with pelvic inlet and outlet views obtained if fractures are identified on anteroposterior view. In the current economic situation, it is doubtful that the routine of all views is warranted, as the diagnostic potential of the additional view, versus the single anteroposterior views, has not been demonstrated. The inlet and outlet views however, provide useful information about the integrity of the

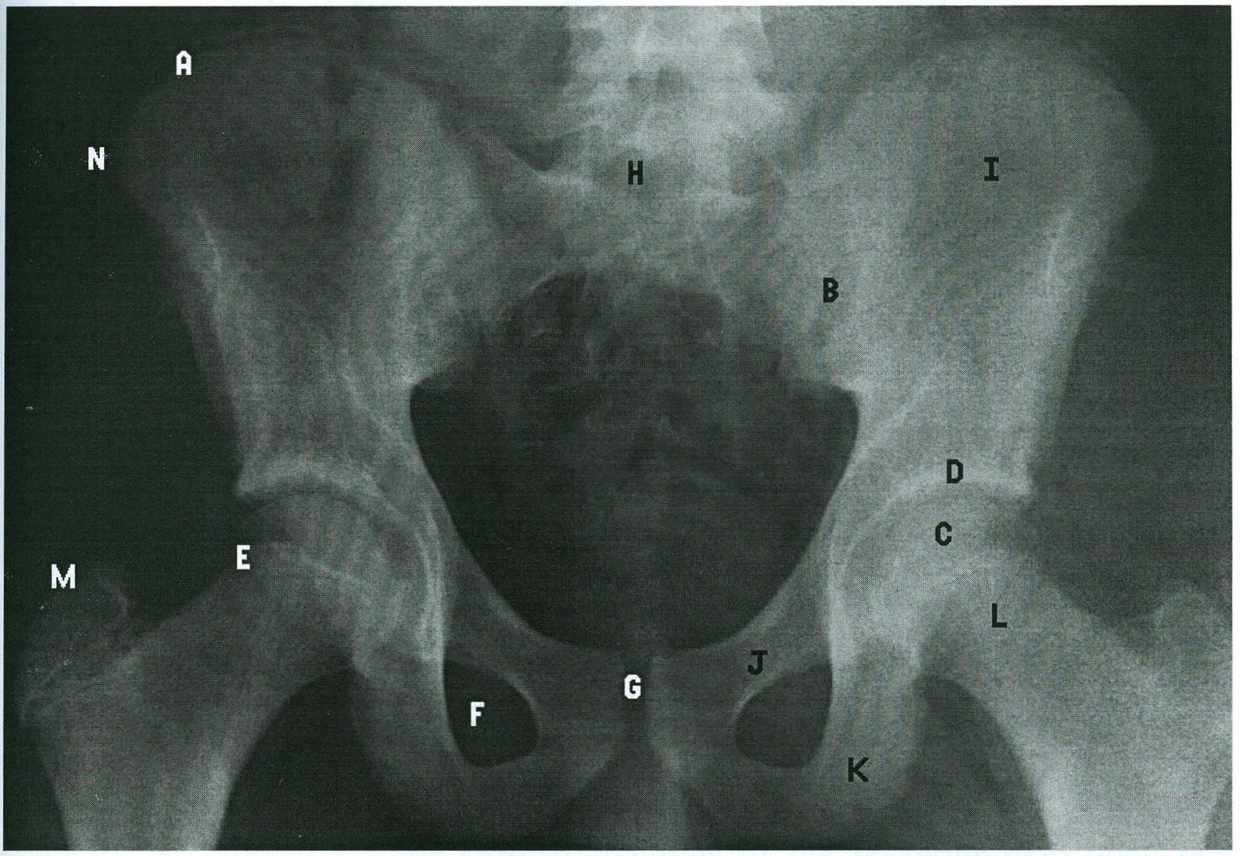


Fig 13: Normal Pelvis

A. Iliac crest
B. Sacroiliac joint
C. Femur head
D. Acetabulum
E. Femoral capital physis
F. Obturator foramen
G. Pubic symphysis
H. Lumbosacral junction
I. Iliac fossa
J. Pubic ramus
K. Ischial tuberosity
L. Femur neck
M. Greater trochanter
N. Anterior superior iliac spine

pelvic ring and the nature and the extent of displacement of fragments of the ring. Judet et al emphasise the importance of oblique view in the evaluation of the acetabulum; however, in this arena Computerized Tomography is clearly superior and if used in conjunction with 3-Dimention reformatting, can provide spectacular representation of the region (24).

Accurate interpretation of the anteroposterior radiograph is essential, and several points have to be emphasised. Fractures of the pubic rami are usually easily detected but must always lead to evaluation of the posterior pelvis. Vertically oriented fractures of ischiopubic rami or innominate bones occur from antero – posteriorly directed forces or from vertically directed forces, where as horizontal fracture of ischiopubic rami occur from lateral compressive forces (9). Thus when the vertical fractures of ischiopubic rami or innominate bone are seen, a search should be made for diastasis of the symphysis and or SI joints as may happen in anteroposterior compression injury or, conversely, for vertical fractures of the posterior iliac wing or sacrum as may occur from vertical shear force. In both vertically and horizontally oriented fractures there may be significant instability of the pelvis, with displacement of the major fragments posteriorly in the case of anteroposterior compression injuries or superiorly in the case of vertical shear injury.

Injuries to acetabulum, in particular posterior pillar, should be sought in cases of anteroposterior compression. The acetabulum should be scrutinized for subtle signs of injury, such as disruption of the posterior rim, visible through the femoral head (25). The anterior rim of the acetabulum is not easy to see but can be seen on most anteroposterior radiographs. As injury to these structures occurs from anteroposterior compression injuries, a search for sacroiliac joint diastasis should be made in-patients with fracture of the anterior or posterior acetabulum. Injury to the medial acetabulum, with or without central hip dislocation, implies lateral compression forces, necessitating a search of the sacral arcuate lines for signs of injury.

In addition to obvious features of displaced fractures and any major disruption to the sysmphysis pubis or sacro-iliac joints, certain subtle signs suggest significant instability;

- Displaced avulsion fracture of the tip of the L5 transverse process
- Avulsion fracture of the Ischial spine

PELVIC VIEWS

a) **Anteroposterior view**

In most cases the anteroposterior film will give sufficient information to make preliminary diagnosis of pelvic fracture. The patient is supine with pelvis symmetrical as for examination of the hip joints, the knees are flexed over a small sacral bay pressure pad placed under the heal.

b) **Lateral view**

Lateral view of pelvis is of limited value. The patient is turned on one side and the central ray is directed over the highest part of the convexity at about the level of the second sacral segment. The thighs and knees are usually slightly flexed. One tries to visualize the pubic symphysis, ischial spines, the tuberosities as well as the entire sacrum and coccyx in this view.

c) **An inlet view;** (the caudad – angled anteroposterior radiography is obtained with tube angled approximately 35degrees, caudad and centered midway between the umbilicus and the pubic symphysis). The cavity of the true pelvis is clearly delineates the position of fragments of the quadrilateral plate, the acetabulum, pubic rami and the component of the sacroiliac joints.

d) **An outlet view;** (the cephalad angled projection, obtained with the tube angled approximately 35 degrees cephalad and centered on the pubic symphysis); is particularly helpful in determining the amount of cephalad displacement of posterior arch fragment or sacroiliac joint disruption.

e) **Right and left oblique views;**

Are designed to demonstrate the appropriate half of the anterior pelvic arch en face. Thus the margins of obturator foramen are completely visualized. Positioning of the patient with a suspected pelvic fracture in the prone oblique position is contraindicated (26). If any serious injury is suspected, a CT Scan at the appropriate level is extremely helpful (some would say essential). This is particularly true for posterior pelvic ring disruptions and for complex acetabular fractures, which cannot be properly evaluated on plain x-rays.

OTHER IMAGING MODALITIES

1. Computed tomography scan

Computed tomography (CT) is superior to plain radiography in providing detail of fractures, position of the fragments, and the extent of diastasis of the sacro iliac joint or pubic symphysis (2,28). It is also superior of evaluating the sacrum and acetabulum. However although conventional computed tomography examination had been cited as simplifying the evaluation of the pelvis in the recent study, Rednik et al determined that only 9% of the pelvic injuries identified by the computed tomography were not seen in plain radiography (17). Further more these were all cases in which the (misses) represented subtle findings that had no effect on patient care.

CT may also be superior to conventional tomography in permitting evaluation of sacrum since the sacrum lies parallel rather than perpendicular to the object plane of conventional tomography. Pelvic and flank hematomas may be life-threatening sequelae of pelvic fractures (40). The CT Image can be displayed to optimally depict the size and location of such collections. At the same examination, CT can be extended to determine the presence or absence of internal abdominal injury, such as damage to the spleen, liver or kidneys.

Because computed tomography is less available and more expensive than radiographs, its value in acute setting has been questioned (29). The advent of spiral computed tomography scanning may change the equation for several reasons. The speed of spiral computed tomography will unquestionably give it an advantage over the more time – consuming conventional computed tomography and plain film radiograph of the pelvis. Conventional radiography may necessitate multiple projections and often requires movement of the patient for positioning of the x-ray plate.

In addition, spiral computed tomography can provide fast computed tomographic angiography with the potential for evaluating the vessels of the pelvis without the need of conventional angiography. Spiral computed tomography could also image all areas of the body rapidly and without further movement of the patient. Its value in evaluating the abdominal organ, thorax, mediastinum, spine, or cranium without moving the patient further cannot be overemphasised. If speed of image acquisition can be correlated to the charges, the cost of the study could become more competitive.

2. Angiography:

In the evaluation of the haemorrhage associated with pelvic trauma, angiography is still the gold standard. Controversy remains in the literature, however, as to when it should be employed. Some authors believe in the aggressive use of angiograph and embolisation of bleeding vessels in the acute phase, where as others prefer the acute application of an external fixation and expectant observation (30). Rationalisation for this approach is the demonstrated decrease in haemorrhage following pelvic stabilisation and the subsequent decrease in the need for expensive and potentially dangerous angiographic intervention.

3. Retrograde urethrography

In cases of suspected urinary tract injury, traditional retrograde urethrography has not been replaced by more modern technologies for examination of the urethra (31). As far as bladder is concerned, retrograde or anterograde contrast evaluation of bladder is still the method of choice in many centers, although, as in other areas of the abdomen, computed tomography has proven to be an effective alternative.

4. Cystography:

Retrograde urethrography is indicated prior to cystography procedure. Foley catheter should not be inserted until it has been determined that the urethra is intact. Cystography is performed with water-soluble contrast and preferably under fluoroscopy. Anterograde cystography; a water-soluble contrast media is used and initial 250cc is introduced and catheter clamped. Anteroposterior and lateral view radiographs of the lower abdominal area are obtained. Identical views after micturation is obtained. The latter views provide information about posterior extraperitoneal injuries that may not be detected when the bladder is full. Flame like extravasations "sun burst" superior or lateral to the bladder indicate extraperitoneal rupture.

Extravasated contrast through the peritoneal cavity, which could outline the bowel and fill the cul-de-sac and paracolic gutters indicate intraperitoneal rupture. Pericytic haematomas may be seen on cytogram as compression on displacement of the bladder. Extravasation of contrast material in the lumen of the bowel or into the vagina may suggest penetration trauma.

5. Radionuclide study:

Radionuclear bone scan may be of value in the non- urgent case to identify occult usually posterior damage not recognized as such on plain films. Bone Scans, however, may be suboptimally sensitive for detection of fractures within 24 hrs of the event, especially in the elderly (41). Radionuclear Technician 99m scan is also useful to assess the viability of testes, especially in blunt trauma

6. Magnetic Resonance Imaging (MRI):

The role of Magnetic Resonance Imaging (MRI) in acute pelvic trauma has not been established or even fully evaluated. The value of MRI in evaluation of the post-traumatic patient shows promise. It has been used successful in the post acute stage, and may have a role in determining prognosis in cases of acetabular or femoral head Injury, hence indicating a specific surgical cause. The predictive value of MRI in the diagnosis of avascular necrosis in the acute stage however has not yet been evaluated. The sensitivity and specificity of MR Imaging are better than those of scintigraphy (4).

7. Ultrasonography

Used as a screening tool to show bladder wall injuries or presence of fluid in the abdomen, but suffers from low sensitivity in excluding bladder injury.

PELVIC INJURY MANAGEMENT

The principle of managing multiple injured patients must be strictly followed and priority must be given to head chest and abdominal injuries. Rapid and aggressive treatment, particularly with regard to vascular injury and visceral injury, and skeletal stabilisation have led to a reduction in mortality and morbidity of patients with major pelvic trauma (13,30). The key to successful immediate management of the patient with major pelvic fracture is timing. Timing will depend on the existence of associated injuries, which take priority, and the presence of early complication like haemorrhagic shock. Treatment of the fracture by reduction should not be instituted until the extent of associated injuries has been determined, because treatment of some of these injuries may be more urgent than the treatment of the fracture (19).

COMPLICATIONS

Fractures of the pelvis are serious in themselves and may result in long-term deformity. Even more important, however, is the fact that they are frequently complicated by damage to the soft tissue. The soft tissue complications include;

i. Bladder injuries – urinoma, fistula (rectum, vagina, bowel, cutaneous), difficulties in voiding and distal ureteral obstruction.
ii. Urethral injuries – strictures, incontinence and impotence.
iii. Penile injuries – Angulation, painful erection and impotence.
iv. Scrotal injuries – infection, loss of testes, skin necrosis, testicular and decreased fertility.
v. Pelvic fractures – infection, delayed union, non-union a vascular necrosis, mal-union, injury to major blood vessels, injury to nerves,

injury to tendons, injuries and post-traumatic affections of joints and fat embolism.

vi. Death; The main cause of death according to autopsy findings are renal failure, fat embolism, thrombo-embolic peritonitis, consumptive coagulopathy and late cardiopulmonary failure.

MATERIALS AND METHODS

This study was done at Kenyatta National Hospital and the Aga Khan hospital X-ray departments on patients referred by the physician or orthopedic surgeons. All were victims of motor traffic accidents, fall from height, gunshot and industrial accidents.

The patient was subjected to the most relevant imaging modality after the request form has been scrutinised and approved by the senior radiologist or resident in the radiological department to avoid unnecessary radiation to the patient. The requested imaging modality was scrutinised to ascertain whether clinical findings tie with the type of examination requested. The following were checked in the request form:

1) General information e.g. Name, age, sex, registration number, out / in-patient or patient referred from other health facilities and x-ray number.
2) Indication for requesting the examination.
3) Relevant clinical findings.

If one modality of imaging failed to give details or was not sensitive enough to that particular pathology, patient was subjected to another type of imaging as suggested by the senior radiologist in consultation with the requesting doctor. Computerized tomography is quite useful because it is possible to do sagittal and coronal reconstruction without re-exposing the patient. This is a great advantage.

The attending radiographer / sonographer or the researcher recorded the personal data of each patient and the cause of injury according to the guideline given (appendix A). The information was obtained directly from the patient or from the person accompanying. The researcher and one of the consultant radiologists interpreted all the patients' diagnostic images. Where necessary, discussions were done by the researcher and the senior consultant radiologist for confirmation of the pathology.

Patients admitted had their ward number noted down by the radiographer for follow up by the researcher every morning. Radiological findings were recorded according to the guideline (appendices A&B).

B - Mode ultrasound scans, were done by using available ultrasound machine with real time transducer of frequency 3.5MHz or 5MHz or 7.5MHz using ultrasound gel as coupling agent. There was thorough examination of the pelvis.

The radiographs were taken by general-purpose unit X – Ray machine. The focus film distance of about 90cm with the patient lying in supine position and oblique positions. The x-ray beam was precisely coned to the pelvis only. Exposure factors were selected appropriately prior to the exposure, to avoid any kind of repeat. During fluoroscopy examination the screening time was as short as possible and precise coning was achieved to minimize unnecessary patient irradiation.

CT Scan: Philips Tomoscan CX \ Q which is a 3rd generation manufactured in 1991 was used. The scanning gantry consists of an x-ray source that produces a highly collimated fan-shaped beam mounted opposite an array of 30 sodium crystalline detectors. The x-ray source and detectors rotate around the patient at 10 increments for a total of 180, with a linear transverse scan occurring at each of the 18 rotational points. A single scan completes in 20sec producing one tomographic scan.

The spiral CT scans were also obtained with available scanner (Sytec synergy = GE Medical System). By using spiral CT scan the pelvis was completely imaged within 30sec. Reconstruction of 0.5mm, 1.5mm, 2.5mm and 5mm were possible by using the same machine. Images were processed at bone and soft tissue window setting. Complete film studies made immediately available to the trauma surgeons.

Sample size determination

These include all pelvic trauma patients seen in the period of eight calendar months. To be able to determine the proportion of pelvic fracture to within 5 percentage points of the true value, minimum sample of 146 patients was required. This sample size was also expected to give a high degree of accuracy and relatively high percentage of confidence level as substantiated by the Fishier Andrew (32)

The following formula was used for sample size calculation:

$$n = \frac{Z^2_{1-\alpha} \times p(1-p)}{d^2} \text{ where}$$

n = sample size to be determined.

Z = standard errors from the mean corresponding to 95% confidence level (1.96).

p = proportion of commonest pelvic fracture.

d = absolute precision (5%).

α = level of significance (5%).

$$n = \frac{1.645^2 \times 0.16 \times 0.84}{(0.05)^2} = \frac{2.706 \times 0.1344}{0.0025} = 145.46 \text{ (approx. 146).}$$

Limitations of the study;

i. The accuracy of the final diagnosis was based on radiologist's report.

ii. CT- breakdown

iii. Financial constrains

Inclusion criteria;

All patients seen in Radiology Department at Kenyatta National Hospital and the Aga-Khan Hospital – Nairobi, with clinical findings suggestive of pelvic injury were included in this study.

Instruments for data collection;

Data collection was done by special designed questionnaire, which recorded the age, sex of the patient, the nature of accident/trauma and the imaging modalities used (Appendix A). Efforts were made to ensure that, the patients understood the questions using interpreters where applicable.

Radiological interpretation were recorded in a special structured form bearing the identified radiological findings (Appendix B)

Ethics (Medicolegal Considerations)

1) Patient's name or religious background was not required in this study. The confidentiality and no use of the patient's information for other purposes than this research were maintained. The patients were identified by their hospital number.

2) No radiological examination was done on a patient apart from one requested by the physician and those were suggested by the senior radiologist in consultation to the requesting physician.

3) All patients were managed to optimal standards as facilities and personnel allow, and no body was denied anything as result of this study. No blood sample was collected during this study nor was any procedure, which simply collect data and was of no benefit to the patient or detrimental to the patient was performed.

4) The result of radiological examination was delivered to the primary physician immediately to assist in management of the patient.

5) Before the study started a request to conduct the study was submitted together with a copy of proposal to the Kenyatta National Hospital and the Aga-Khan Hospital ethical and research committee and was approved.

DATA MANAGEMENT:

Supervision of data collection;

During pattern assessment procedure it was ascertained that the forms were properly filled. Therefore at the end of a day all forms were checked and reviewed by the researcher for correction of mistake, clarification and completeness. The forms were coded and edited before entry of data in computer.

Proper data entry in Microsoft computer

Checked data were then encoded on floppy diskettes and printed out from computer and also transferred to the computer take up system. Patients' data were then analysed on a Microsoft computer using the statistical package for the social sciences (SPSS).

Results (Representation of Data);

This is in form of tables and graphs to fulfil aims/objectives. Representative films are presented in photographs for demonstration and illustration.

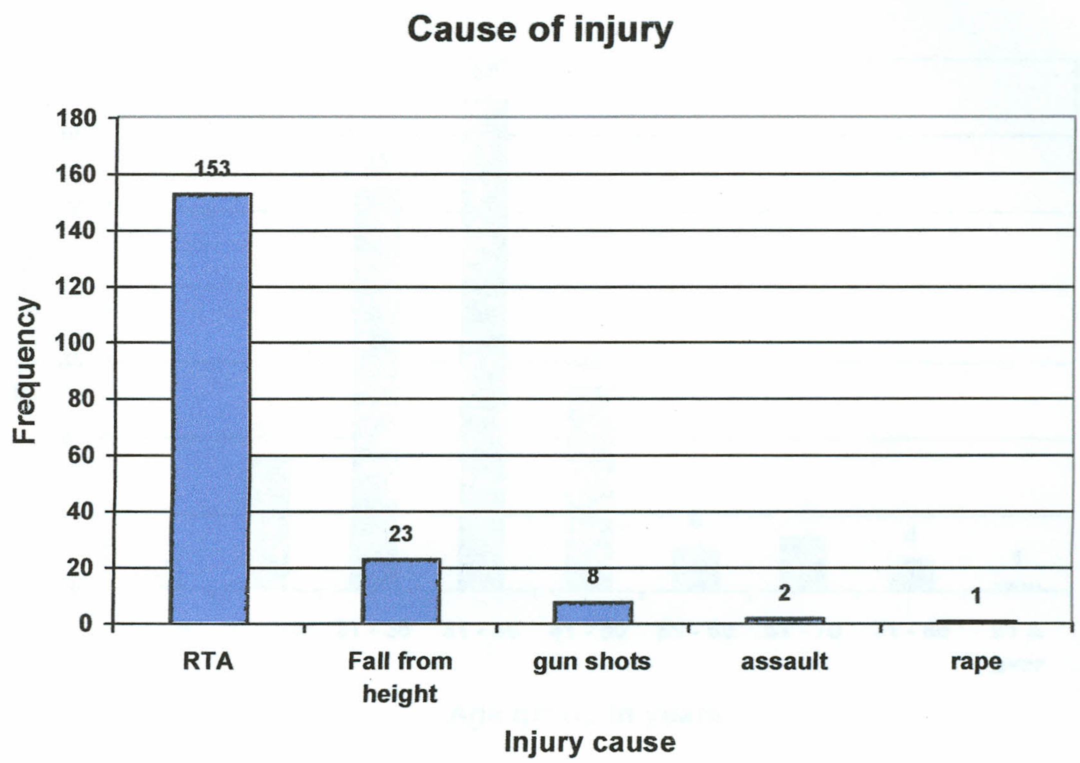
RESULTS

Imaging modalities	Frequency	Percentage
X – ray	186	98.4
Ultrasound	2	1.1
CT Scan	26	13.8
MCU & ASC	16	8.5
Total	230**	121.8*

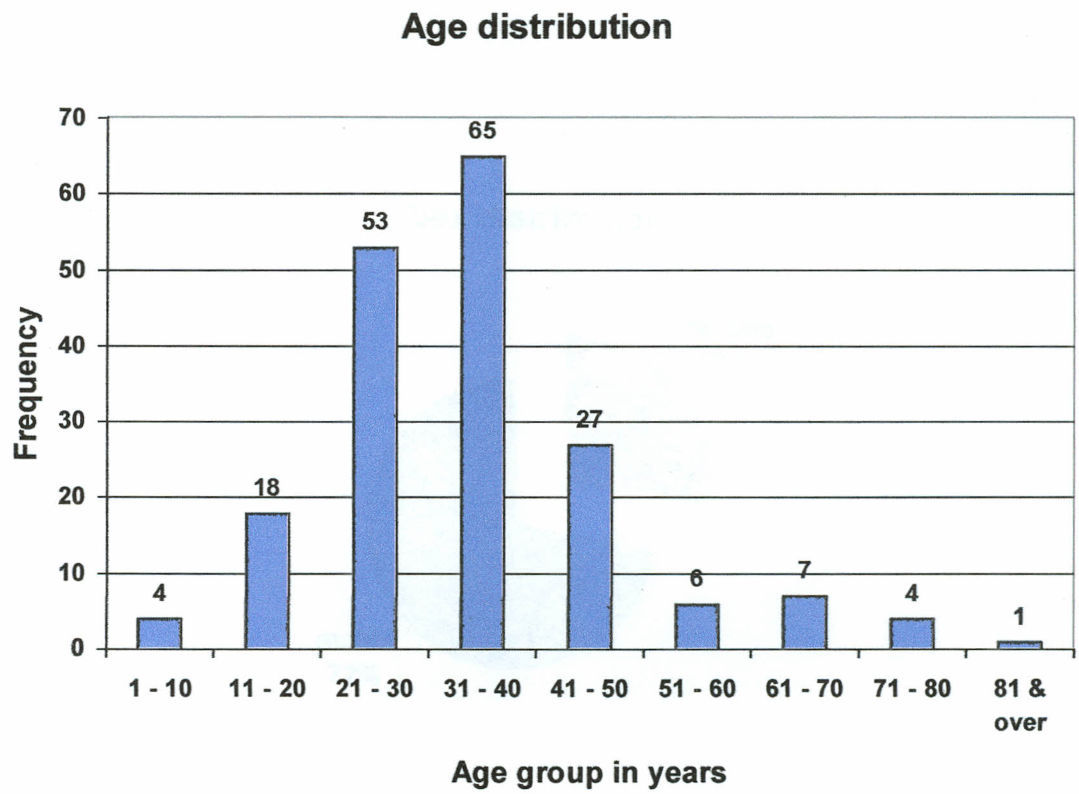
Table 1: Frequency of imaging modalities

** = Imaging modalities (Table 1) constituted a total of 230. This is because some patients in the study group had a combination of more than one type of imaging modality.

* =The proportion of imaging modalities constitutes 121.8%. This is because some patients were exposed to more than one imaging modality, and the proportions were computed from the actual study population data (189).



Graph 1: Road traffic accident was the dominant cause of injury



Graph 2: Of the study population, the age group 21-50 years which is the most economically viable is also the most vulnerable to injury.

Sex distribution

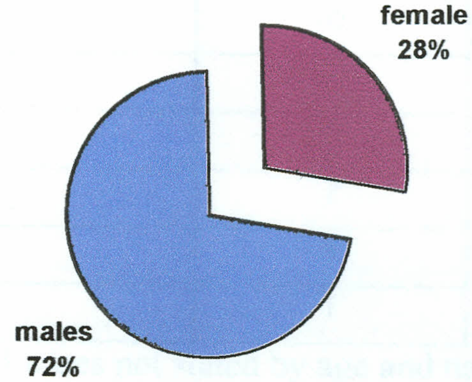


Chart 1; Shows that there were 136 (72%) male and 53 (28%) female patents.

Age group in years	Frequency	Percentage
1 – 10	4	2.2
11 – 20	18	9.7
21 – 30	53	28.6
31 – 40	65	35.1
41 – 50	27	14.6
51 – 60	6	3.2
61 – 70	7	3.8
71 – 80	4	2.2
81 & over	1	0.5

4 cases not stated by age and name.

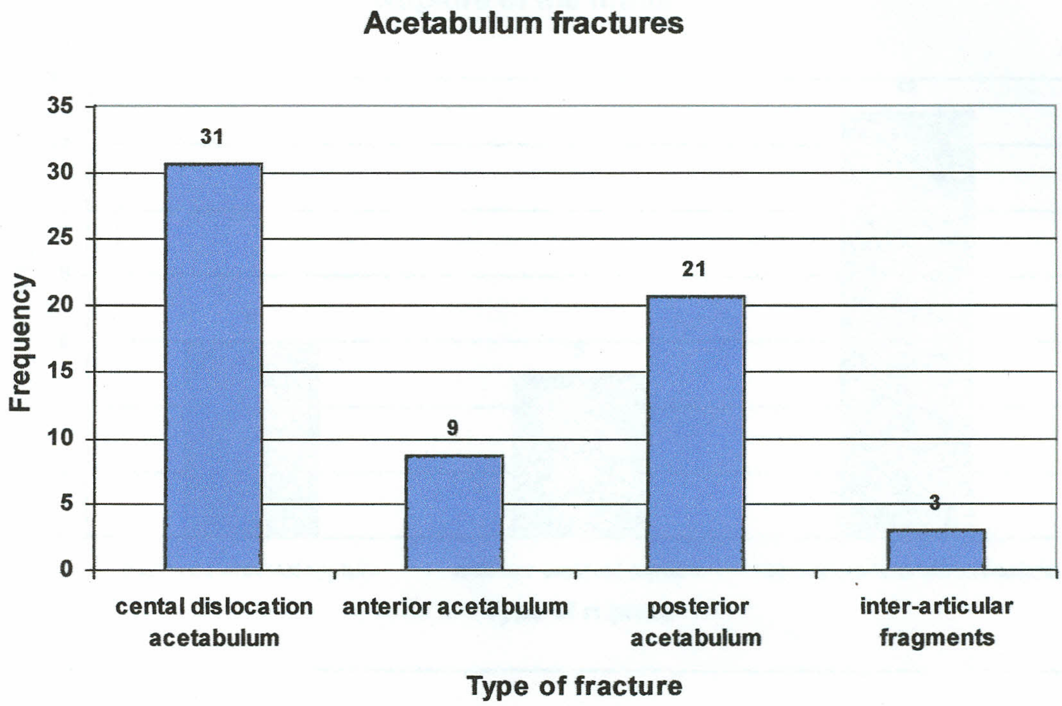
Table 2: Age distribution

There were a total of 185. This is because four cases were seriously injured, unconscious and their age could not be established.

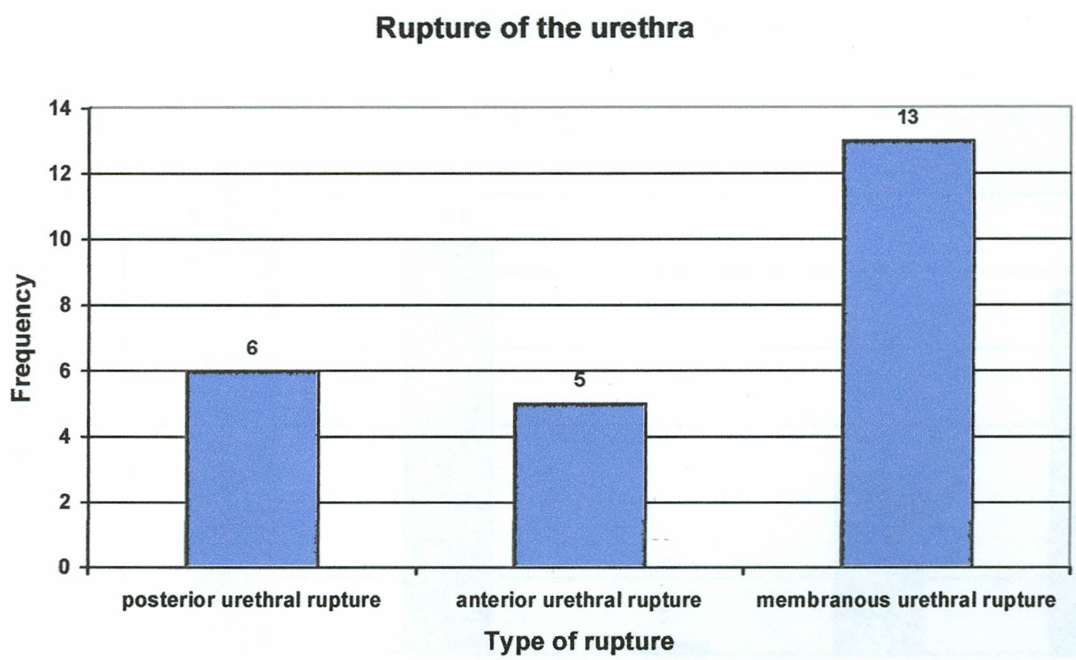
Type of Pelvis Injuries	Frequency	Percentage
Ischiopubic rami fracture	97	51.3
Acetabular fracture	64	33.8
Straddle fracture	8	4.2
Malgaigne fracture	4	2.1
Sacral junction	5	2.6
Urethral injuries	24	12.7
Bladder injuries	6	3.2
Bucket handle fracture	11	5.8
Hip dislocation	15	7.9
Normal pelvis	23	12.2
Pubic diastasis	19	10.1
Iliac bone fracture	15	7.9

Table 3: Frequency of presenting pelvic injuries

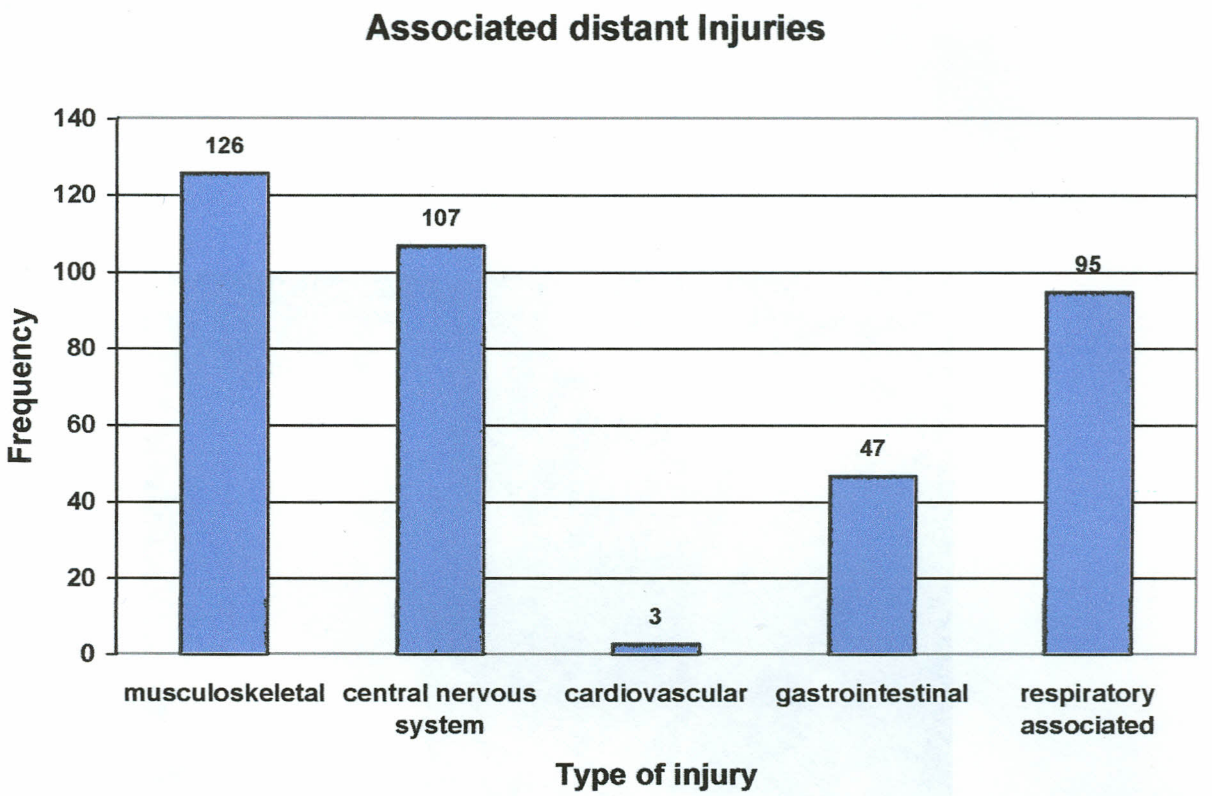
Table 3 shows the results of pelvis injuries. There were a total of 295. This was due to some patients having a combination of more than one type of bony and soft tissue injuries.



Graph 3: Acetabular fracture associated with central dislocation was the dominant acetabular injury



Graph 4: Of the urethra rupture, membranous urethra was the most affected in pelvic injury.



Graph 5: Of the associated distant injuries, majority of the patients had musculoskeletal followed by central nervous system and respiratory system injuries

RADIOGRAPHIC AND COMPUTED TOMOGRAPHIC IMAGES

In this study, various imaging modalities like plain radiography, computed tomography and ultrasound scans were used. Illustration 1 to 18 represent some of the various pelvic fractures and soft tissue injuries that were seen during the study period.

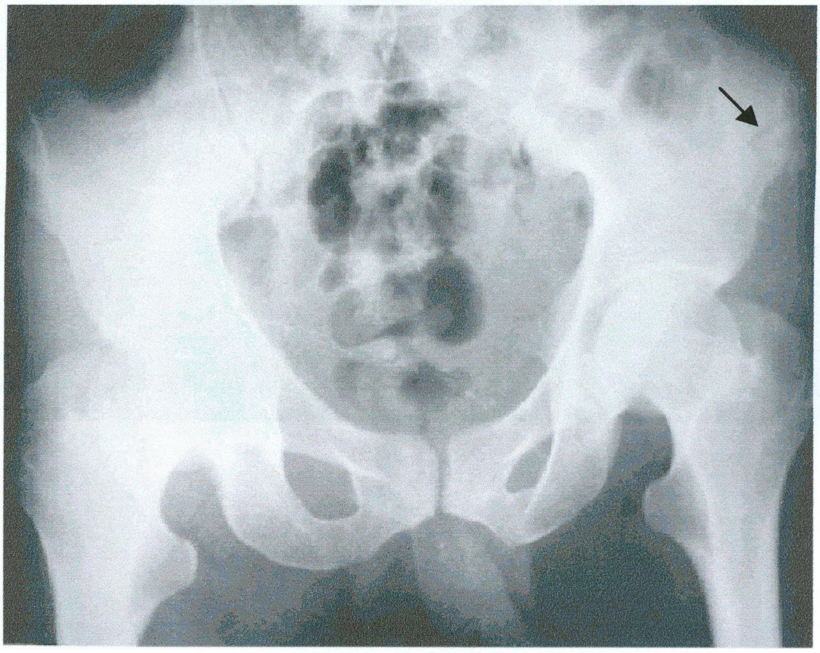


Illustration 1:

Fracture fragment of left iliac bone is shown.

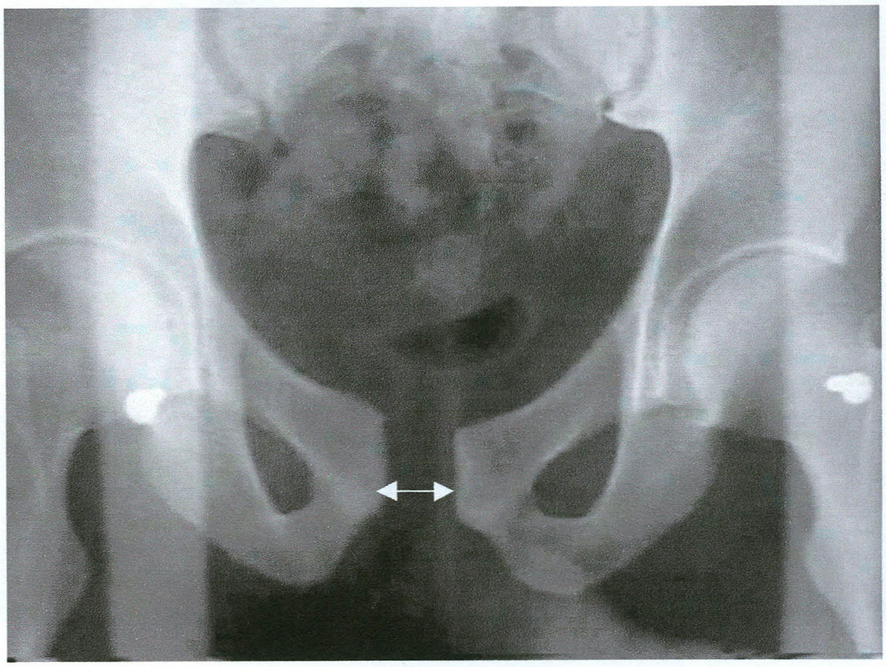


Illustration 2

There is wide diastasis of the symphysis pubis

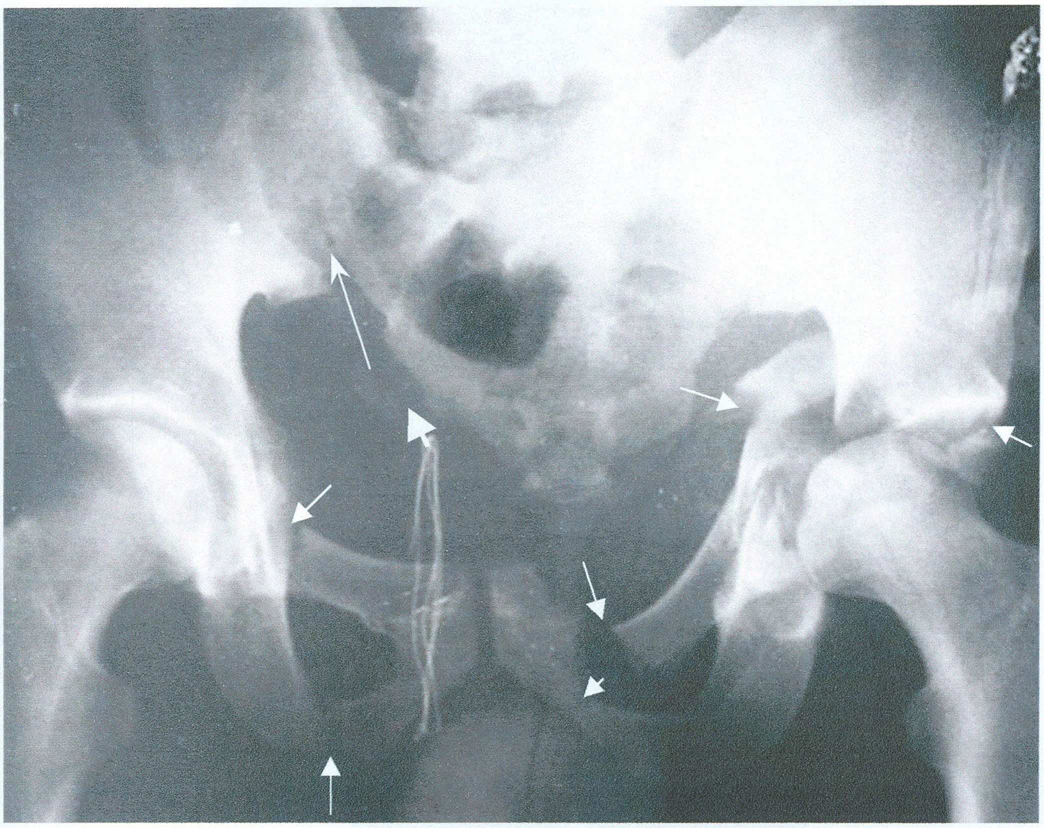
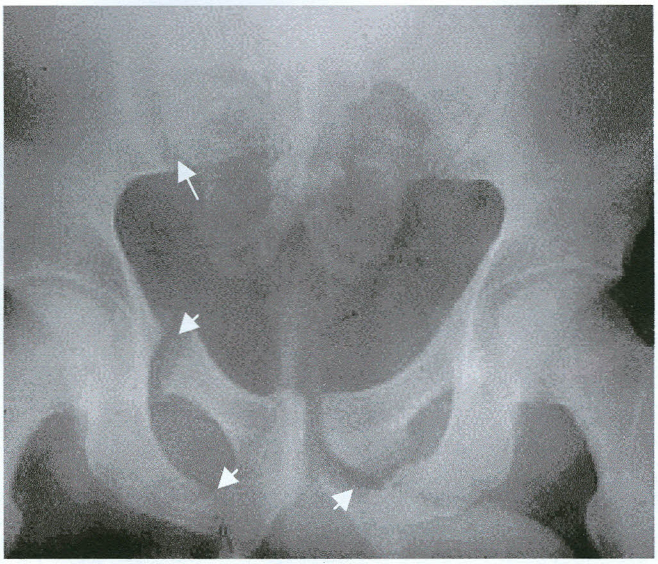
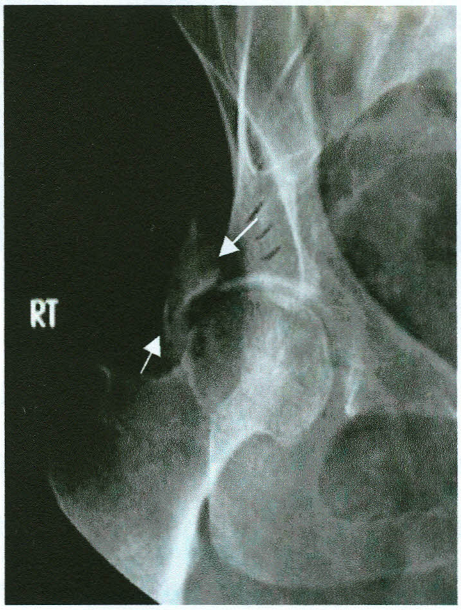


Illustration 3 : Complex fracture of the ring;

Both left and right inferior and superior pubic rami fractures (Arrows) have occurred with fragment displacement. Fracture fragments (Arrowhead) on the right aspect of the sacrum and subluxation of the sacroiliac joint (long arrow). Comminuted left acetabular fracture with mild central dislocation is evident.



(A)



(B)

Illustration 4:

(A) Pelvic ring disruption consisting of fractures of the right superior and inferior pubic rami. Fracture of the left pubic bone and diastasis of right sacroiliac joint (arrow) are also seen.

(B) Displaced fracture fragment (arrows) of the right posterior lip of acetabulum after reduction of the right hip dislocation.

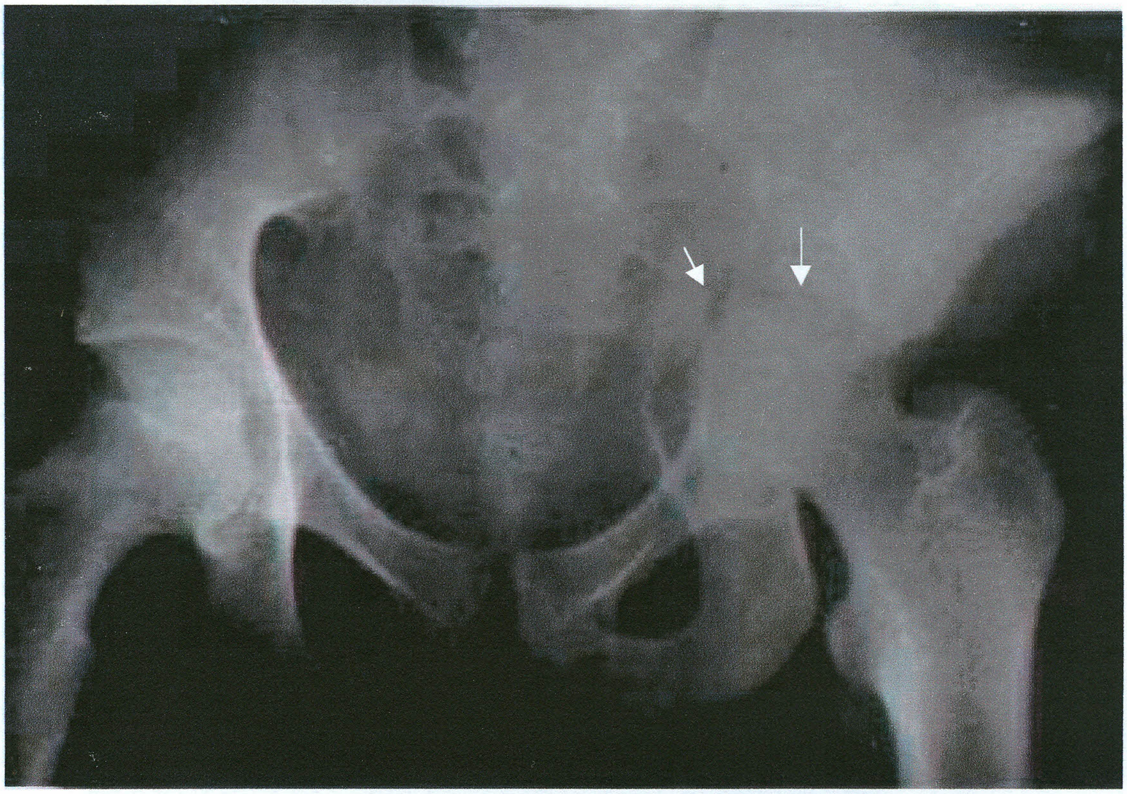


Illustration 5:

Left acetabular fracture (arrows) with central dislocation. These fractures are classified as type I , II and III, depending upon whether there is minimal, moderate or complete protrusion of the femoral head.

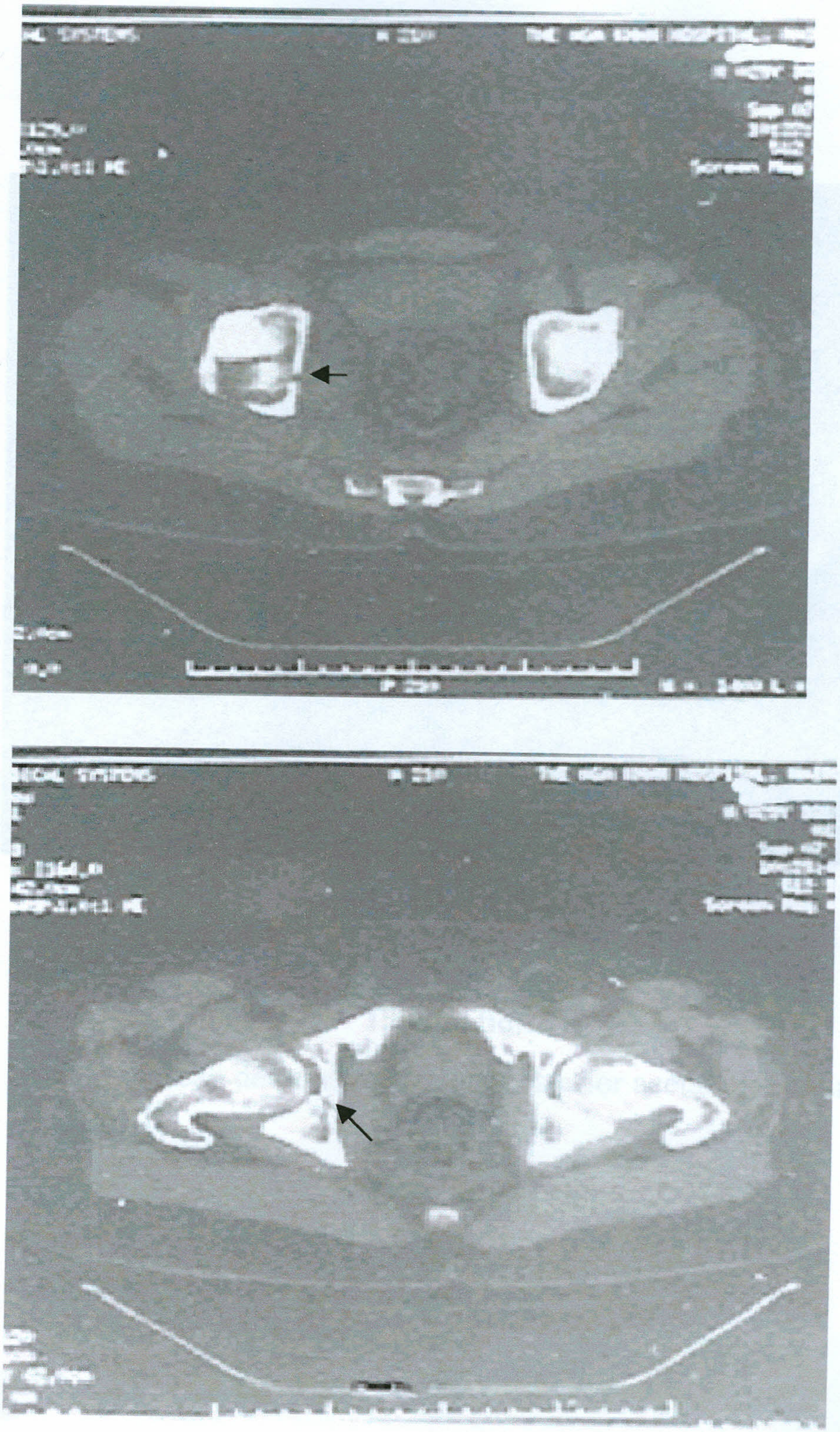


Illustration 6:

Axial CT-scan images: Demonstrates central right acetabular fracture.

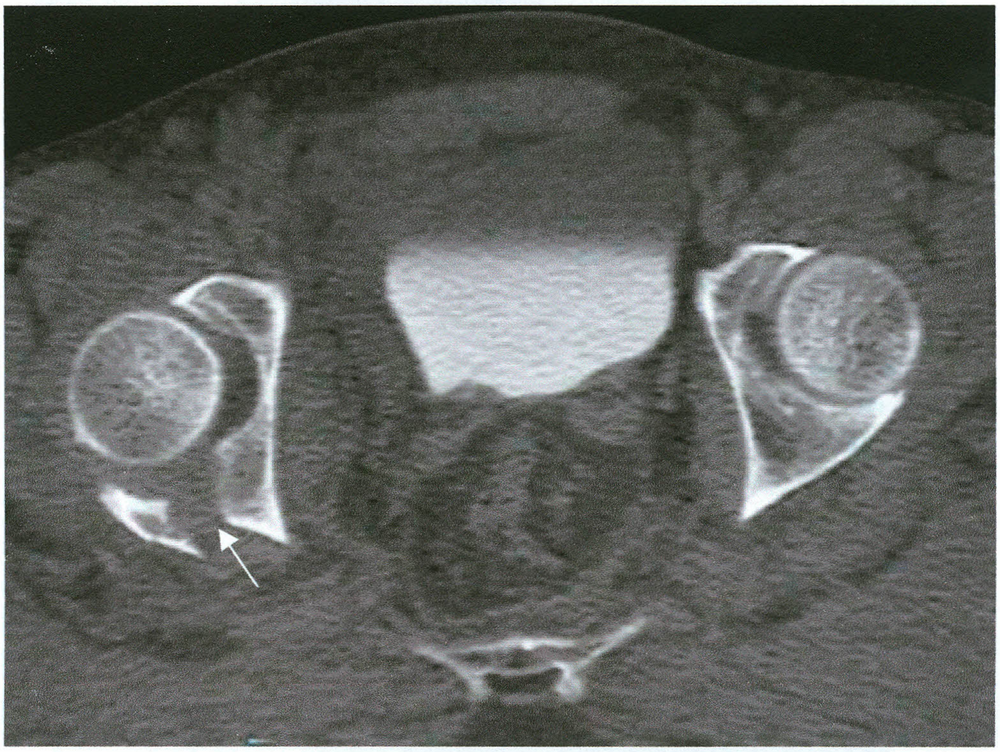


Illustration 7:

Axial CT-Scan demonstrates right posterior acetabular column fracture (arrow).

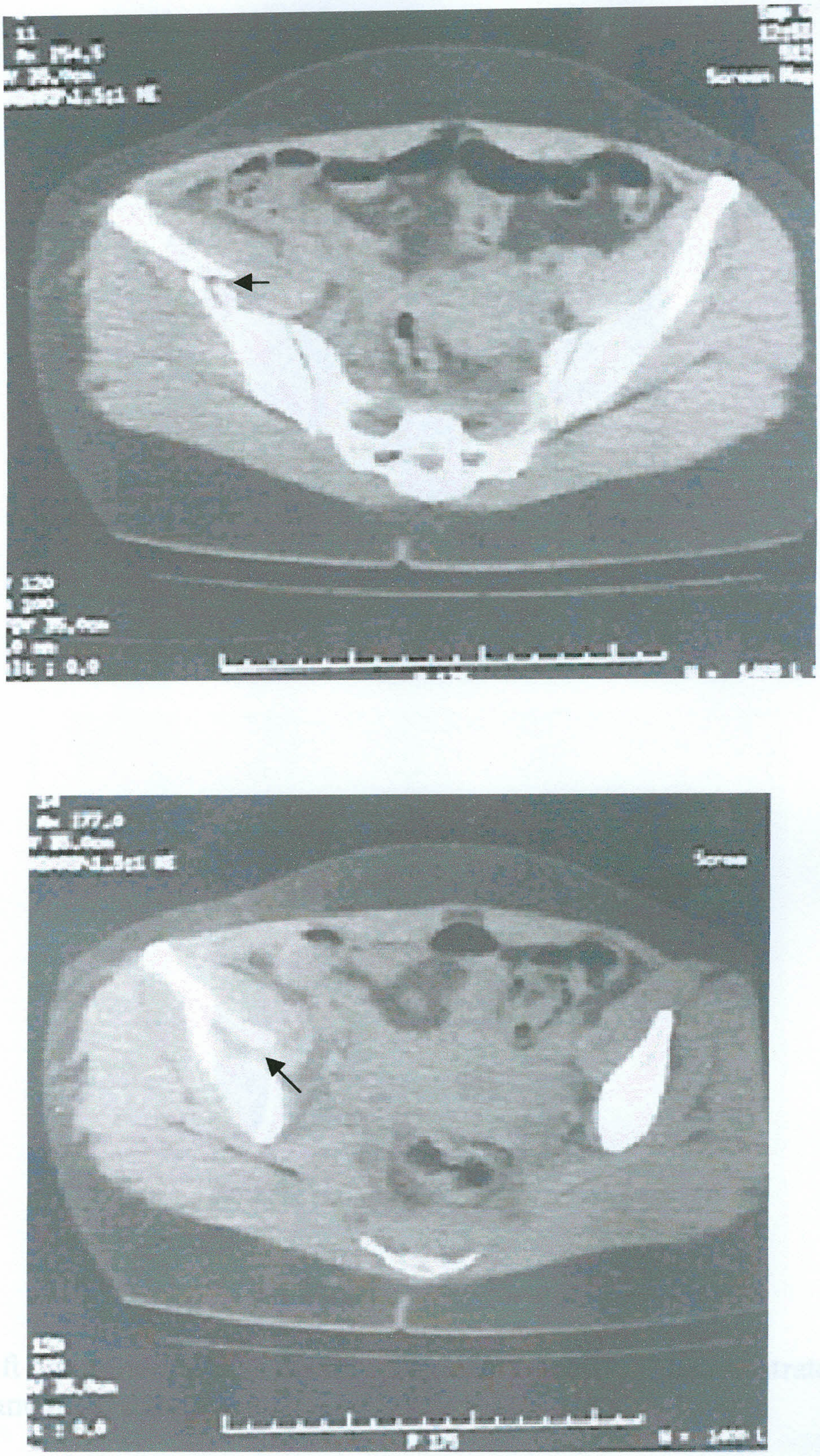
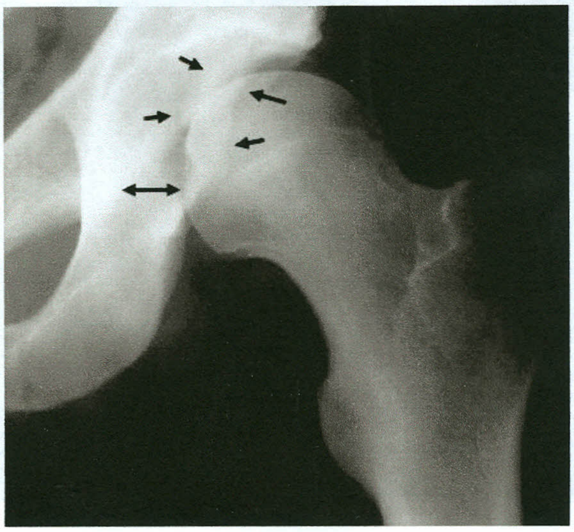
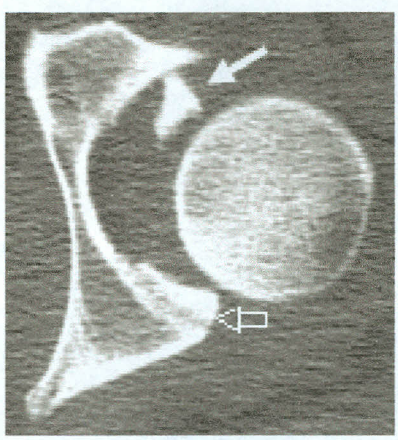


Illustration 8:

Axial CT- Images, demonstrates extensive fracture of the right iliac bone (arrows).



(A)

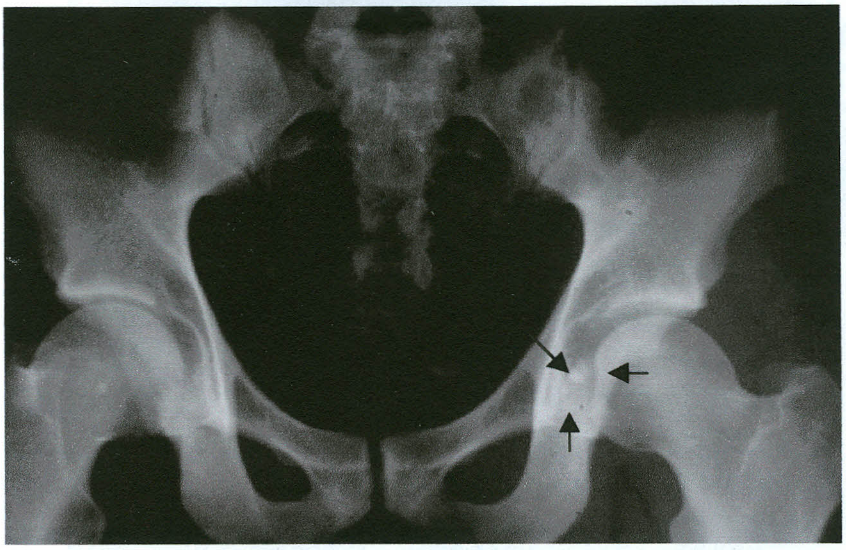


(B)

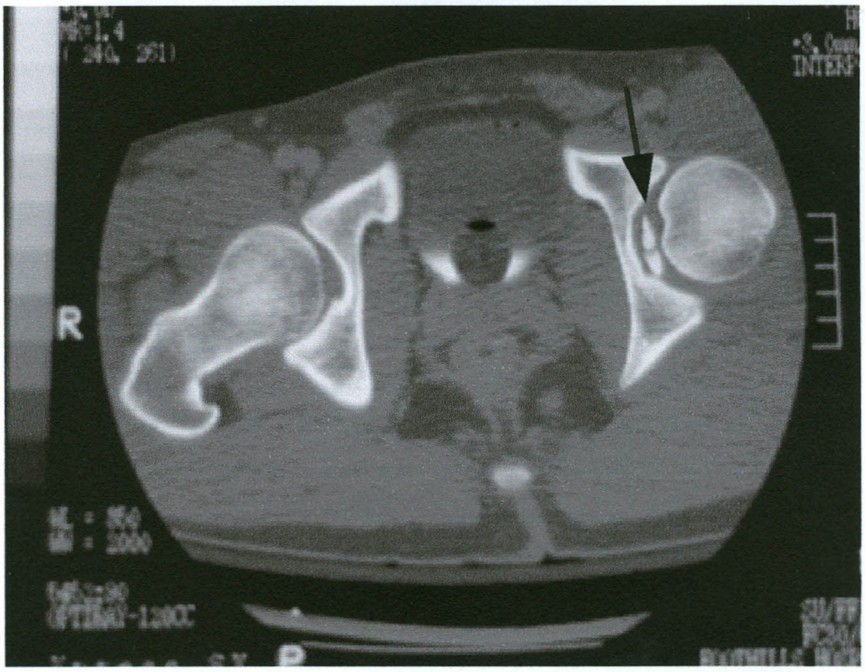
Illustration 9:

(A) Left hip intra-articular fracture fragment (arrows) is demonstrated after manual reduction.

(B) Axial CT-Scan of the same patient reveals two intra-articular fracture fragments (arrows).



(A)



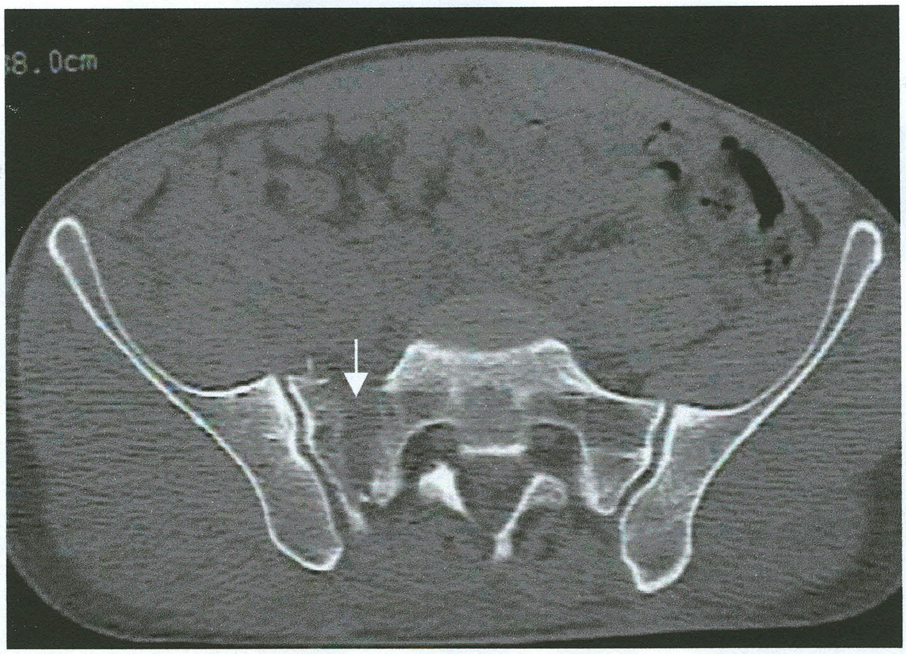
(B)

Illustration 10:

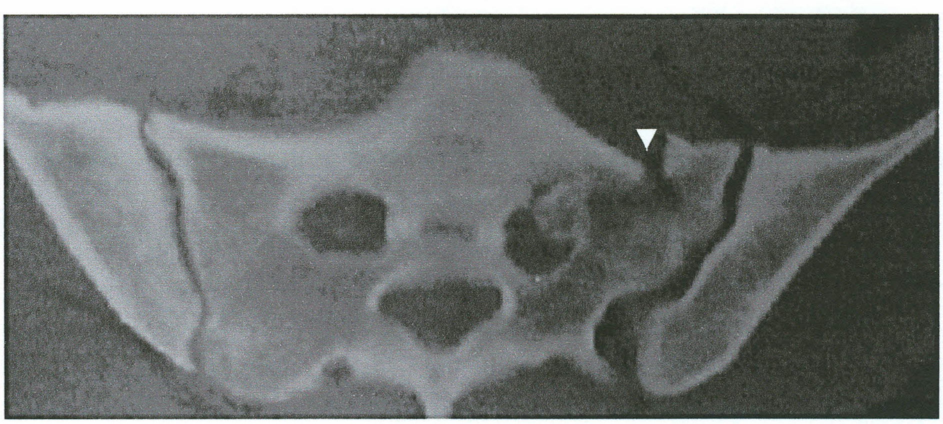
(A) AP radiograph of the pelvis demonstrates left intra-articular fracture fragment (arrows).

(B) Axial CT-scan of the same patient at the acetabular level demonstrates intra-articular fracture fragments (arrow).

Illustration 11:
Axial CT-scan demonstrating comminuted fracture (arrows) of the left sacrum and associated with subluxation of the right sacroiliac joint(arrowhead)



(A)



(B)

Illustration 12:

(A) Fracture of the right sacrum is shown on axial CT-image (arrow).

(B) Fracture of the left sacrum is also demonstrated (arrowhead).

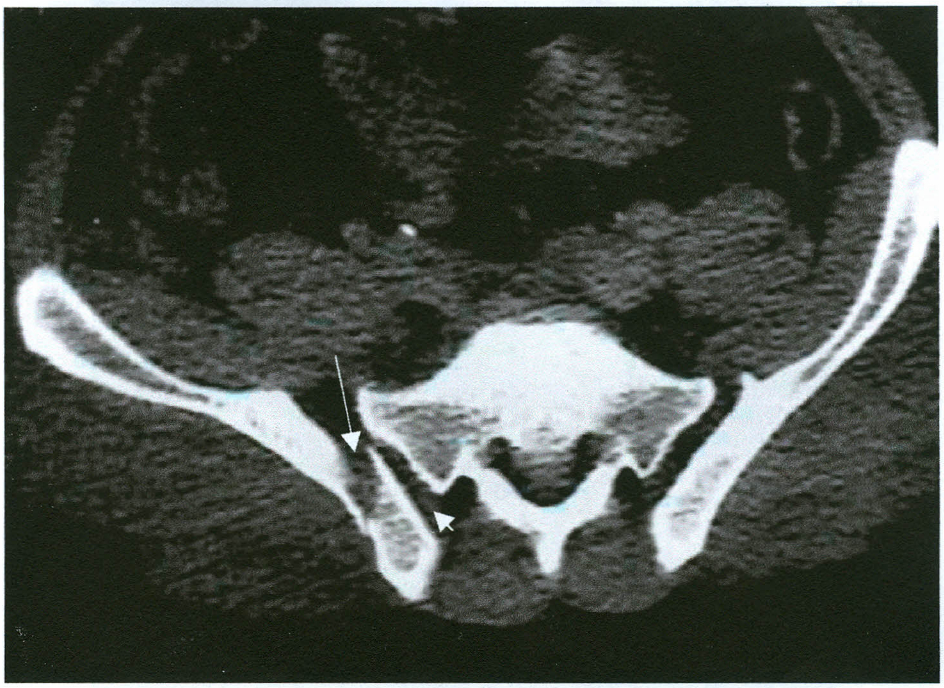


Illustration 13:

CT-image demonstrates fracture of the right iliac bone (arrow) with diastasis of ipsilateral sacroiliac joint (arrowhead)

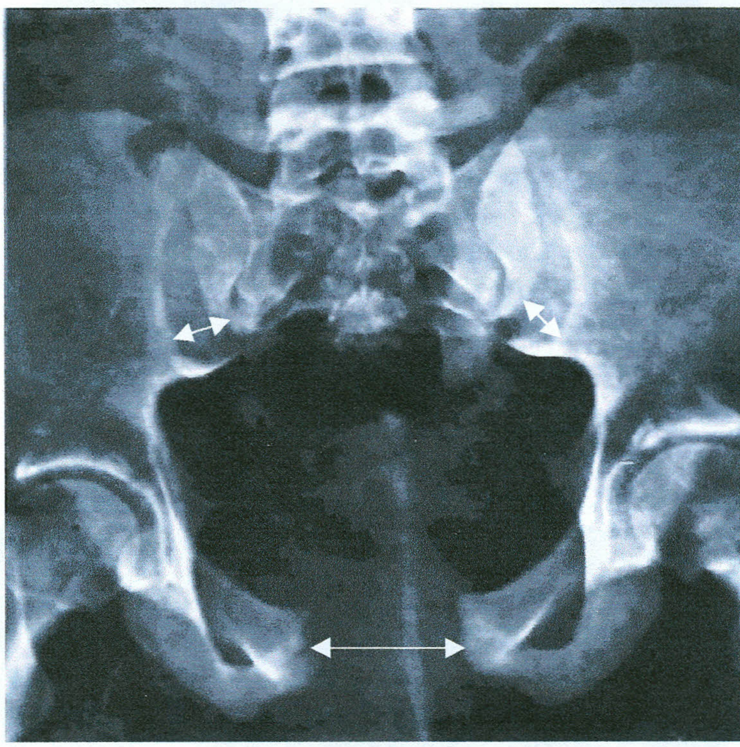
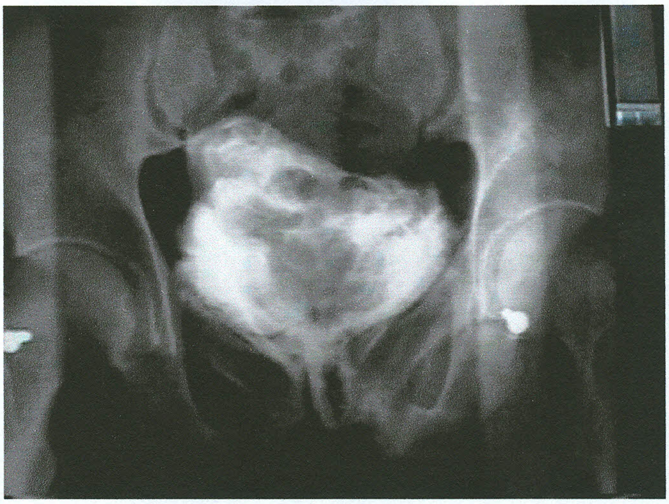
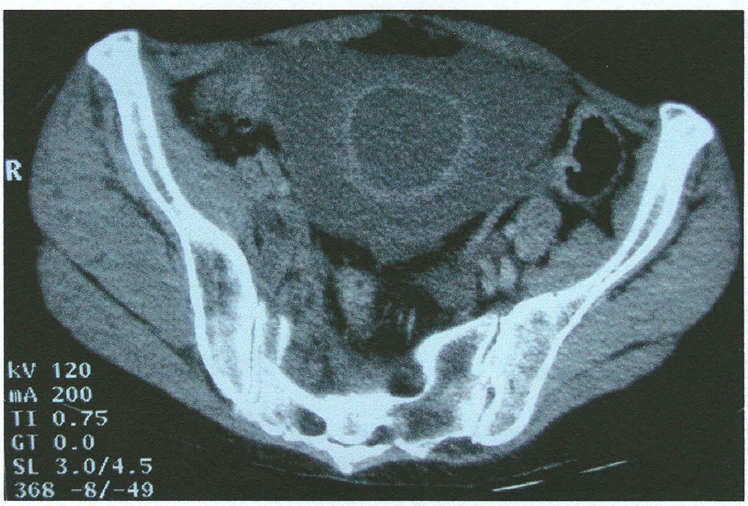


Illustration 14:

Double open book fracture with separation of the symphysis pubis and both sacroiliac joints.



(A)



(B)

Illustration 15:

(A) Intravenous urogram demonstrates haematoma of the urinary bladder wall.

(B) CT-image of the same patient demonstrates haematoma of the urinary bladder wall

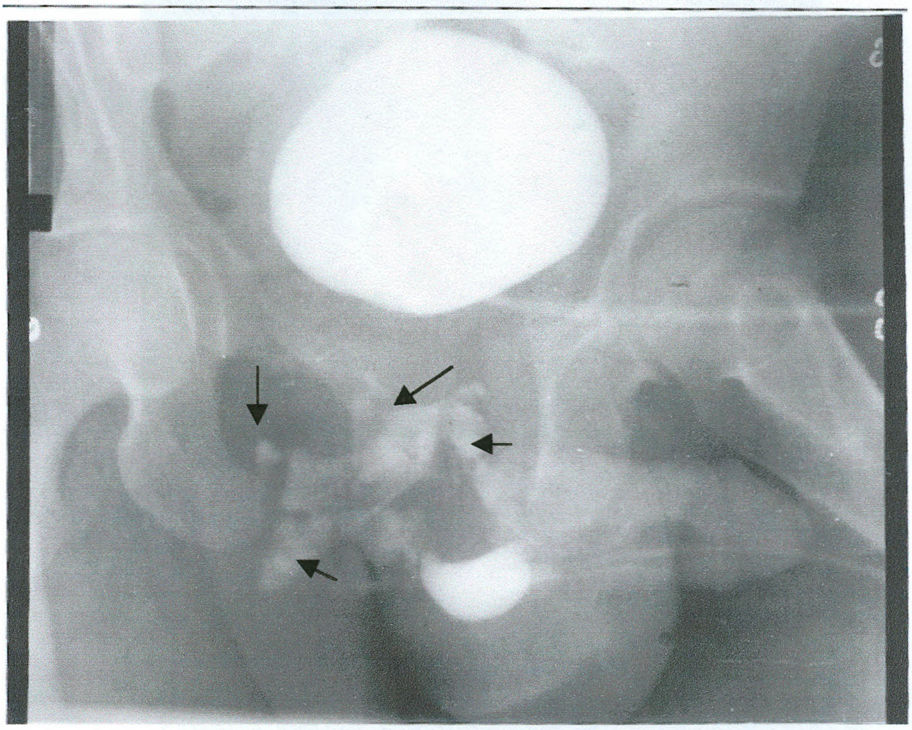
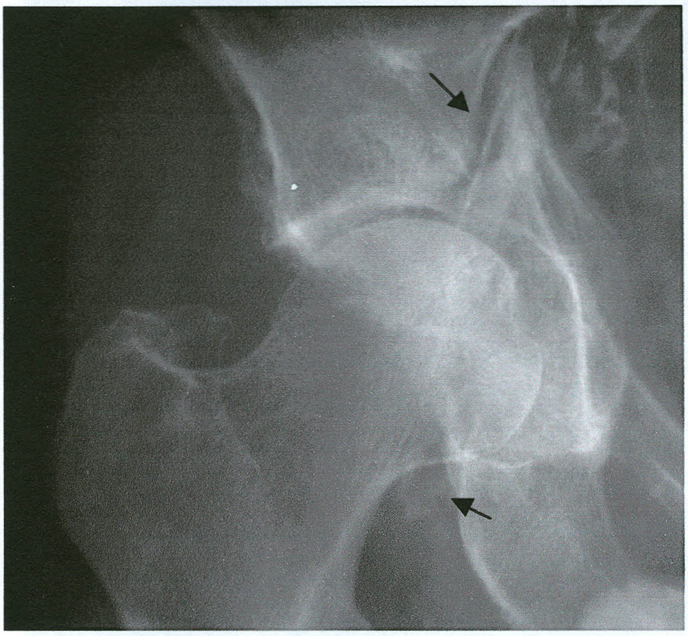
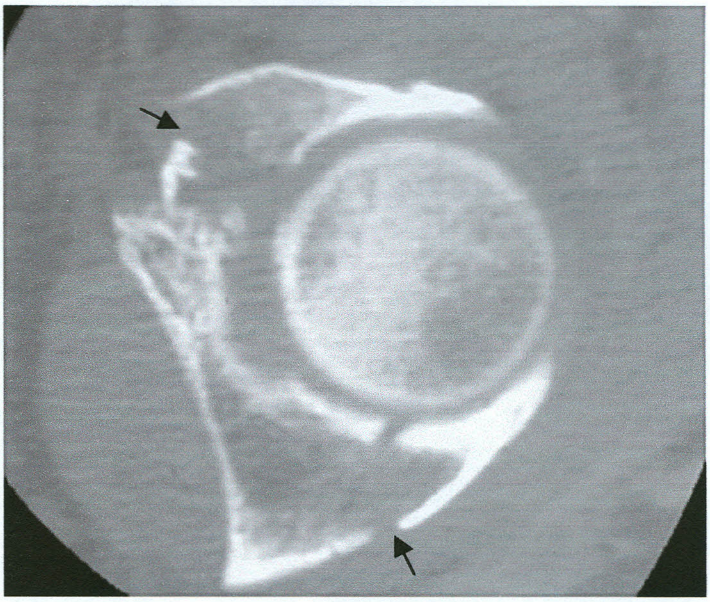


Illustration 16:

Combined ascending urerthrogram and cystourethrograph showing extravasation of contrast in soft tissues as the result of posterior urethra rapture. Separation of pubic symphysis is evident.



(A)

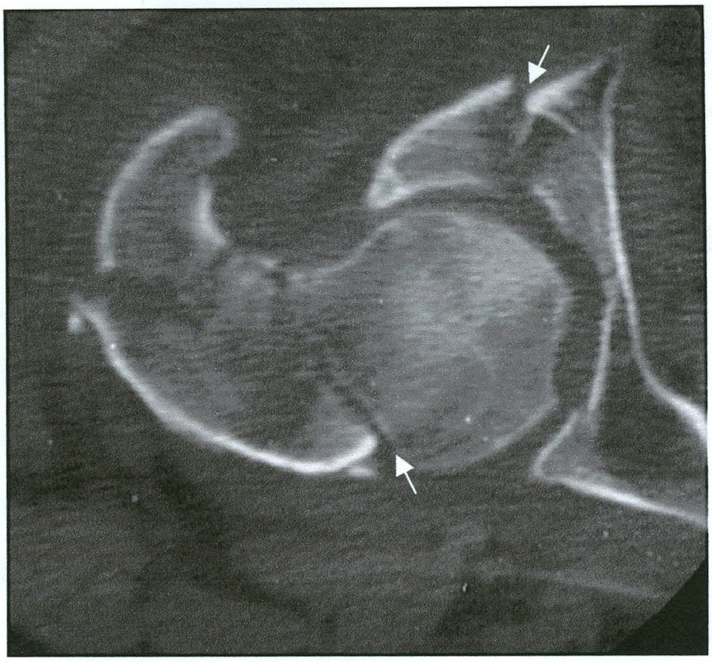


(B)

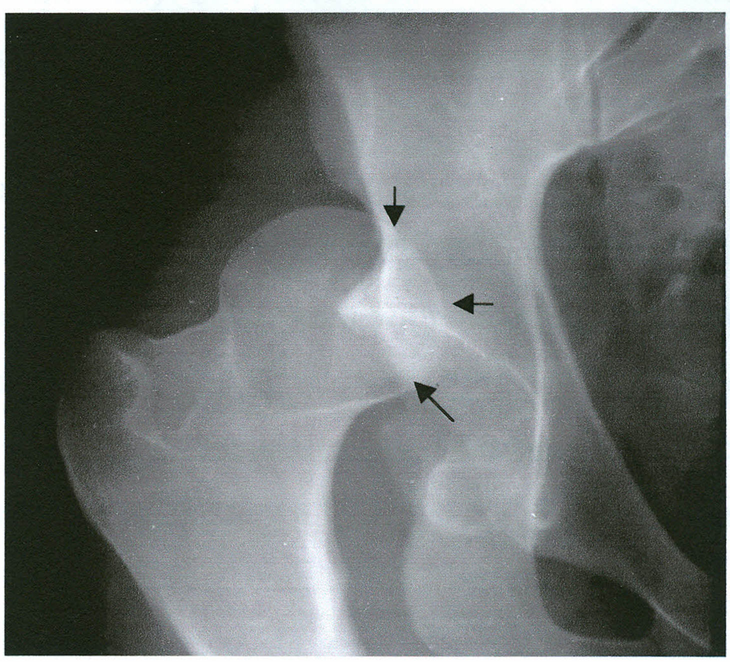
Illustration 17:

(A) AP radiography of right hip showing communited fracture of the acetabulum involving both posterior and anterior column.

(B) Axial CT-image of the same patient at the acetabular level shows the fracture of the posterior and anterior column.



(A)



(B)

Illustration 18:

(A) Axial CT-image. This demonstrates a fracture of the neck of the femur and the anterior column of the acetabulum.

(B) AP radiograph of the right hip demonstrates posterior dislocation of the hip.

DISCUSSION OF RESULTS

The aim of the study was to determine the pattern of pelvic trauma and possible associated soft tissue injury as shown by various imaging modalities in Nairobi-Kenya. The study was carried out at Kenyatta National Hospital and the Aga Khan Hospital-Nairobi, between May, 2001 and December 2001 (eight calendar months). One hundred and ninety five (195) patients were prospectively entered into the study. All patients were either victim of Road traffic accidents, fall from height, assault, gunshot, rape or industrial accidents.

Of one hundred and ninety five (195) patients, 189 patients qualified for inclusion in this study. Six patients were excluded because they died before the examination.

Study group demographic data

The group studied included 136 (72.0%) males and 53 (28.0%) females whose age range from 0-80+ years with male female ratio of 2.6:1 (Chart I). The mean age in male and female were 35.1 and 33.6 respectively while the mode for male and female were 34.0 and 19.0 respectively. Four unconscious patients (unknown by name and age) were also included in the data.

The prevalence of pelvic injuries due to accidents was found to be higher in the age group 21-50, which had 77.3 per cent. This coincides with the most socio-economical viable age group, and agrees with findings in other studies (33). The least affected groups were 1-10, and 5I-80 years (graph 2 and Table 2). The result agrees with previous reports in Nairobi and Nigeria that, the large proportion of road traffic accident victims is aged between 20 – 50 years (33).

Diagnostic Imaging procedures

This was mainly plain film radiography, as discussed in the literature review section. Some patients (98.4%) underwent plain radiography, 13.8 per cent underwent CT – Scan; cystography and retrograde urethrography added up to 8.5 per cent. Ultrasound mainly of the pelvis 1.1 per cent (Table 1).

The low prevalence of the patients who underwent CT scan in Nairobi can be explained by the fact that, the procedure is more expensive and usually more specific after patients specific evaluation. Plain radiography in Nairobi-Kenya is about sixteen times cheaper as compared to CT Scan of the pelvis and is readily available in casualty.

Sixteen patients (8.5%) with haematuria following pelvic injury underwent both micturation cystourethrography and retrograde urethrography with retrograde urethrography proceeding cystourethrography to establish the integrity of the urethra. Two patients (1.1%) with bladder and liver rupture underwent pelvic and abdominal ultrasound examination (table 1).

Causes of Injury

Of the study population (189 patients) with pelvis injuries, 153 patients (80.9%) were attributable to road traffic accidents and twenty-three patients (12.2%) fall from height (Graph.1). In another study, the prevalence of the pelvis injury caused by road traffic accidents was 87% (34). The apparent mild fall of prevalence rate in Nairobi as compared to other previous studies can possibly be explained by increased awareness about road traffic accidents, improvement of the roads and new driving regulations.

Other pelvic injuries were attributed to gunshots (eight patients) 4.2%, assault (two patients) 1.1% and rape (one patient) 0.5%. In twenty-three patients (12.2%) including, four unknowns by name and sex with suspected pelvic injuries, their radiograph results were normal.

Pelvic fractures

In literature review above, it is documented that the fractures of ischiopubic rami are the most common injuries of the pelvis (35). In this study the most frequent pelvic injuries were ischiopubic rami fractures 97 (51.3%), of these patients 55 (29.1%) had superior pubic rami fractures and 42 (22.2%) had inferior pubic rami fractures. Twenty-six patients (13.8%) had both inferior and superior pubic rami fractures (Table 3 and illustration 4a). These findings agree with the study carried out in U.S.A by Grogg A. Bogust et al in which obturator ring and/or pubic rami fracture were the most frequent type of pelvic fractures followed by acetabular fractures (41).

Of the 97 (51.3%) patients with ischiopubic rami fractures, 8 (4.2%) had straddle fractures (fracture of all four pubic rami). Eleven (5.8%) patients had bucket handle fractures (with complete disruption of the pelvic ring). The rest of patients had either superior rami fracture or inferior pubic rami fracture (table3).

Fractures of the acetabulum

The second commonest type of pelvic injury is the fracture of the acetabulum, 64 (33.9%). The role of CT in evaluation of the acetabular trauma is well established (25). Acetabular fractures are classified using the system of Judet and Letourne. It is generally possible to group patients in a specific subcategory of this classification scheme by assessment of plain radiographs. CT evaluation can provide precise information regarding relative alignment of fracture components and identification of intra-articular fracture fragments (illustration 9 and 10). The presence of intra-articular fragments may need surgical removal. It is important therefore, the specific fragment is identified and either be aligned by manipulation or removed from the joint. These fragments may be occult on radiographs and may not be apparent to the surgeon in the operating room.

Among 64 (33.9%) patients with acetabulum fractures, 31(16.4%) had acetabular fractures with central dislocation (illustration 5), 21(11.1%) had posterior acetabular column fractures (illustration 5), 9 (4.8%) had anterior acetabular fractures (illustration 18a) and 3 (2.1%) had intra-articular fracture fragments (Graph 3). A comparable study carried out by Paul S Potok et al in United States of America, twenty seven per cent (27%) of the patient had posterior acetabular column fracture and 5% had anterior column fractures (42). The axial CT scan is the standard anatomical plane for visualizing acetabular fractures. In the past, 5-mm collimation was considered standard protocol; 3-mm collimation protocol is however employed in acetabulum imaging in many centers including the center of my study. With spiral CT-Scanning, the acetabulum can be imaged in less than one minute. Various plains can be obtained by reconstruction, and assess damage of the acetabular in all planes.

Making multiplanar and 3 – D reconstruction in acetabular injuries has very useful reconstruction that allows the visualisation of the acetabular wall as well as hip joint and shows any associated dislocation.

Disruption of pelvic ring

Of all examined patients, 93 (49.2%) had shown stable pelvic fractures while 52 (22.5%) had unstable pelvic fractures. In another study the prevalence rate of stable pelvic fractures account for two-third of all pelvic fractures (14). In this study the prevalence of stable pelvic fractures accounts half of all patients with pelvic fractures. The slight difference of low prevalence of stable pelvic fractures in Nairobi may be explained by difficulty in plain radiography interpretation because of superimposition of other structures. In stable fractures, the fracture of the ilium (illustration 1) account for 15 (7.9%). Most result from a direct lateral force that medially displaces the iliac wing usually its anterior half (35).

Unstable fractures are important, because of their inherent severity, and the associated serious complications. The complications commonly include diastasis of pubic symphysis, fractures of pubic rami, combined with dislocation of sacro-iliac joint or fracture through the body of the ilium. In this study 52 (22.5%) of the patients had unstable fractures with the associated complications as shown in Table-3.

Hip dislocation

The study revealed that 6 (3.2%) patients had posterior dislocation of the hip (illustration 18b), while 1 (0.5%) had anterior hip dislocation. Of seven patients (3.7%) with hip dislocation five (2.6%) had posterior acetabular column bone fragment (illustration 7 and17b), and two (1.1%) had intra-articular fracture fragment (illustration 9) after reduction was done.

The person at greatest risk of posterior hip dislocation is often the front-seat passenger in a car involved in a head-on collision. A force is transmitted along the shaft of the femur to the flexed hip. With the femur in adduction simple posterior dislocation of the femoral head may occur. If the femur is abducted to any degree a fracture-dislocation involves the posterior wall of the acetabulum. Such an injury is stable.

In the presence of a dislocated hip, it is better to reduce the hip prior to CT-scanning. Reduction can potentially restore vascular supply to the femoral head and thereby decrease the chance of vascular necrosis. In addition closed reduction of dislocated hip can cause a realignment of the acetabular fragments. A possible cause of failure in reduction of a dislocation is the presence of bone fragments in the joint.

Fractures of the sacrum

Of the 52 patients with unstable fractures, a sacral fracture was noted in five patients (2.6%) (illustration 11 and 12). When a shear force is applied obliquely across the pelvis, bony failure does not occur in compression, and the ligaments support is less able to resist disruption and therefore the potential for instability in both a lateral and vertical plane is greatly increased. This can occur to one or both sides of the pelvis creating a very unstable situation. In this study seven patients (3.7%) had vertical shear injury (Malgaigne fractures).

Soft tissue injury

In the study, there were 24 (12.7%) patients with ruptured urethra (illustration 16). Of the twenty-four patients (12.7%), six patients (3.2%) had posterior urethral rupture, five patients (2.6%) had anterior urethral rupture, and thirteen patients (6.9%) had membranous urethral rupture (Graph 4). Six patients (3.2%) with posterior urethral rupture had also straddled fracture and pubic symphysis disruption. This is comparable to other studies, in which the posterior urethral ruptures are seen in 3-10% in association with pelvic injury (17).

Ruptured urinary bladder was seen in six (3.2%) of the patients (illustration 15). This was mainly due to assault. A comparable study carried out in United State of America also show that, 5 – 13% of pelvic trauma patient with abdominal injuries had genital urinary involvement (14).

The presence of compound pelvic fracture (illustration 3) with associated major vessel injury and distant organ injury has morbidity of approximately 50% especially if associated with a major head injury. In this study 88.7% had musculoskeletal injury, 71.4% had central nervous system injury, 2.1% had cardiovascular associated injury, 33.3% had gastroinstenstinal injury and 66.7% had respiratory associated injury (Graph 5). These results can be compared to the study done in United Kingdom by Magnus I Molaren at el. 1990 in which incidence of injuries associated with pelvic fracture were, masculoskeletal 89%, Respiratory 60% central nerve system 40% gastrointestinal 30% and cardiovascular 6%.

Pelvic fractures are a common consequence of high-speed collisions and occupational accidents, because strong external forces are necessary to produce a fracture in a normal pelvis (37). The importance of pelvic fractures lies in the high rate of morbidity and mortality, the latter approaches 30% mainly because of associated injuries to different organs and systems; Cardiovascular, gastrointestinal, respiratory, central nervous system and genitourinary (36). These results are summarised in (Table 3 and Graph 5).

There is dramatically decreasing mortality and morbidity rate with rapid diagnosis and multidisciplinary management and aggressive approach to treatment, as in improvement in Diagnostic, and the therapeutic technique, like preoperative angiography, computerised Tomography, Magnetic Resonance Imaging, therapeutic embobilization, external fixation, and early open reduction with internal fixation. Little progress has been made in treating the chronic disability that is a consequence of late complications of pelvic fractures, including nonunion, malunion, leg length discrepancy and low back pain. In this context, low back pain which frequently persists after pelvic ring injures and represents a major cause of invalidity, may be due to the pelvic obliquity, sacroiliac joint instability, or associated lumbosacral junction injury with faulty weight bearing axis (37). Therefore an accurate restoration of the anatomy of the pelvic ring is essential to the improvement of survival and the reduction of morbidity.

It has been shown that an optimal evaluation of posterior ring element injuries cannot be accomplished with conventional radiographs alone, especially in cases of sacral fracture, which occurs in 40% - 74% of the cases and is often diagnosed late or is even overlooked on radiographs (38). CT demonstrates sacral and sacroiliac joint fractures, the extent of comminution, the rotation of the hemipelvic fragments and the status of posterior aspect of he sacro-iliac joint (illustration 14). It is therefore recommended in all cases to define the residual mechanical stability of the pelvic ring (34).

However more studies are needed to define the sensitivity and specificity of CT in the diagnosis of pelvic injuries, in comparison with intra - operative findings and long term follow up findings.

CONCLUSION

Pelvic injuries (82.0%) are mostly attributable to road traffic accident and the modality of investigation is mainly plain radiographs (98.4%). In this study the most frequent pelvic injuries were ischiopubic rami fractures followed by acetabulum fractures. The study shows that, there is significant association of pelvic fractures and visceral injuries, example, posterior urethra and urinary bladder ruptures. It has also been revealed that axial plane CT is particularly useful in demonstration of fractures of the pelvic ring, the posterior acetabular margin, the presence of intra-articular fracture fragments, the sacral and sacroiliac joint fractures.

CT – Scanner also demonstrates the most common associated pelvic fracture complications like; femoral head injuries, pelvic haematoma following soft tissue injuries, and resulting pelvic asymmetry.

Due to pelvis complex anatomy the conventional radiographs have long, poorly visualised the traumatised pelvis. This study shows the superior value of CT in the investigation and evaluation of pelvic injuries, in order to reduce mortality and morbidity that ensures after pelvic injuries.

RECOMMENDATIONS

1. Despite the small number of patients with sacral injuries associated with pelvic injuries, the prevalence of this injury is over looked on the basis of radiographic findings, because of poor resolution and the tendency of bowel contents to obscure pelvic anatomic details. I therefore recommend that, pelvic CT-Scans that includes the region of lumbosacral junction be obtained in all patients with severe pelvic injuries.

2. A fast scanning unit or spiral CT Scan is recommended especially for semi conscious, un-cooperative patients, and patient with severe pelvic injuries.

3. From this study the findings and results reported are not adequate to show the extent and effects of pelvic injuries following Road Traffic Accidents (RTA). Therefore a continuos epidemiological study is needed to determine the extent, the type, effects and management of pelvic injuries in this era of increasing automobile accidents.

4. The effects of seat belts should also be evaluated in relation to pelvic injuries, and appropriate recommendations given.

APPENDICES.

APPENDIX A ---- QUESTIONNAIRE

Hospital Number……….

A. General information.

(Tick / fill wherever applicable)

1. Name of the patient……………………………………..…

2. Age of the patient in years / months………………………

3. Sex / Gender (a) Male ………………

(b) Female ………………

4.Occupation ………………………

	MODALITIES OF IMAGING						
CAUSE OF TRAUMA	Conventional x-ray	Computerized Tomography scan	Intravenous urogram (IVU)	Ultra sound Scan (U/S)	Radio-nuclide scan	Angio-graph	Magnetic resonance imaging (MRI)
Motor vehicle							
Motor cycle							
Bicycle							
Pedestrian							
Falling from heights							
Gunshots							
Stab injury							
Others							

APPENDIX B - RADIOLOGICAL INTERPRETATIONS.

1.Radiological findings

(a) Site / region ....

(b) Fractures; Yes ....No..........................

(c) Type of fracture; (i)..........................

(ii)..........................

(d) Other local findings (i)..........................

(ii)..........................

(e) Dislocation; Type (i)..........................

(ii)..........................

(f) Pelvic organs; (i) Distal ureter.........(ii) Urinary bladder ......

(iii) Urethra; (a) Proximal...(b) Membranous.. (c) Distal...

(iv) Uterus.............

(v) Rectum............

3.Radiological findings in other organs

(a) Head \ neck................

(b) Spine....................

(c) Chest....................

(d) Abdomen (i)Spleen......................

(ii) Liver.......................

(iii) Kidney ....

(e) Extremities.....................