Sudan University of Science and Technology

College of Graduate Studies

A Study of Incidental Findings among Patients with Lower Back Pain using MRI

دراسة النتائج العرضية للمرضى الذين يعانون من آلام أسفل الظهر باستخدام التصوير بالرنين المغناطيسي

A Thesis Submitted for the Requirements of the partially fulfillment of the Award Msc. Degree in Medical Diagnostic Radiology

Presented By

Mawda Ali Mohammed Osman

Supervisor

Dr. Mona Ahmed Mohammed

2019

الآية

بسم الله الرحمن الرحيم

قال تعالى:

(يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ)

صدق الله العظيم

المجادلة : 11

Dedication

To my father

To my mother

To my teachers

To my family

To my friends

Acknowledgement

I wish to thank all those helped me, without them I could not have completed this project.

This research could not have written without Dr. Mona Ahmed Mohammed who not only served my supervisor but encouraged me.

To colleague in Yastabshiroon Medical Center, radiologists, technologist and staff of reception.

To who helped me I gave them my great thanks.

Abstract

This was a prospective analytical study to detect the incidental findings in reporting rates and clinical importance of spinal findings that were incidentally detected on the magnetic resonance imaging (MRI) involved 50 patients (22 males, 28 females) carried out at period between February 2018 to February 2019 in Yastabshiroon medical center in Omdurman.

The result shown that most (56%) of participants were females, since (44%) of them were males, (30%) of participants were more than 65 years old, since (22%) of them were 46-55 years and (20%) of them were 56-65 years, while (18%) of them were 36-45 years, whereas only (10%) were 25-35 years old. Therefore, most of the participants were more than 45 years old. shown that the diagnoses for (36%) of participants was hemangioma, since for (30%) of them was abscess, while for (18%) of them was secondary collapse and for (10%) of them was traumatic collapse, whereas for only (4%) of them was lesions and for only (2%) of them was cyst.

The probability of hypothesis that differences in "diagnoses" are related to gender is not supported and a diagnosis does not dependent on gender, and age is not supported and diagnoses does not dependent on age. Incidental findings were common, most were benign and awareness of the prevalence of the incidental findings detected at MRI is helpful for diagnosing lesions not related to symptoms.

مستخلص البحث

كانت هذه دراسة تحليلية مستقبلية للكشف عن النتائج العرضية في معدلات الإبلاغ والأهمية السريرية لنتائج العمود الفقري التي تم اكتشافها بالمصادفة في التصوير بالرنين المغناطيسي (MRI)التي شملت 50 مريضًا (22 ذكرًا و 28 أنثى) تم إجراؤها في الفترة بين فبراير 2018 إلى شباط 2019 في مركز يستبشيرون الطبي بأم درمان.

وأظهرت النتائج أن غالبية المشاركين (56٪) كانوا من الإناث حيث أن (44٪) منهم من الذكور و (30٪) من المشاركين تزيد أعمارهم عن 65 سنة حيث أن (22٪) منهم تتراوح أعمارهم بين 46-55 سنة (20٪) منهم تتراوح أعمارهم بين 56-65 سنة ، بينما (18٪) منهم تتراوح أعمارهم بين 36-45 سنة ، بينما (10٪) فقط تتراوح أعمارهم بين 25-35 سنة لذلك ، كان عمر معظم المشاركين أكثر من 45 عامًا. تبين أن تشخيص (36٪) من المشاركين كان ورم وعائي حيث أن (30٪) منهم كان خراج بينما (18٪) منهم كان انهيار ثانوي و (10٪) منهم كان انهيار رضحي فقط (4٪) منها كانت آفات و (2٪) منها كانت كيسة.

إن احتمال فرضية أن الاختلافات في "التشخيصات" مرتبطة بالجنس غير مدعوم ولا يعتمد التشخيص على الجنس ، والعمر غير مدعوم والتشخيص لا يعتمد على العمر. كانت النتائج العرضية شائعة ، وكان معظمها حميدة والوعي بانتشار النتائج العرضية التي تم اكتشافها في التصوير بالرنين المغناطيسي مفيد في تشخيص الآفات التي لا تتعلق بالأعراض.

List of Contents

List of tables

List of figures

List of abbreviation

AS	Ankylosing Spondylitis
CAT	Computed Axial Tomography
CSF	Cerebro Spinal Fluid
CSF	Cerebrospinal Fluid
CT	Computed Radiography
DDD	Degenerative Disc Disease
DLSD	Degenerative Lumbar Spine Disease
FOV	Field of View
FSE	Fast Spin Echo
GRE	Gradient Echo
IAP	Inferior Artecular Process
IFs	Incidental Findings
ISL	Inferior Spinous Ligament
L_1	First Lumbar Vertebra
L_2	Second Lumbar Vertebra
L_3	Third Lumbar Vertebra
L_4	Fourth Lumbar Vertebra
L_5	Fifth Lumbar Vertebra
LBP	Lower Back Pain
LCS	Lumbar Canal Stenosis
MRI	Magnetic Resonance Imaging
RF	Radio Frequency
S1	First Sacrum Vertebra
SE	Spin Echo
SPSS	Statistical Package for Social Sciences
T_1	Longitudinal Relaxation Time
T_2	Transvers Relaxation Time
TE	Time to Echo
TR	Time of Repeat

Chapter one

Introduction

Chapter one

1-1 Introduction

The lumbar vertebrae are, in human anatomy, the five vertebrae between the rib cage and the pelvis. They are the largest segments of the vertebral column and are characterized by the absence of the foramen transversarium within the transverse process (as it is only found in the cervical region), and by the absence of facets on the sides of the body. They are designated L1 to L5, starting at the top. The lumbar vertebrae help support the weight of the body, and permit movement (Michael F et al 2008).

Incidental findings (IFs) are usually asymptomatic abnormalities other than expected pathologies, which are encountered during radiological examinations. In recent years, advances in digital evaluation of radiological imaging (e.g., high magnification zoom, the ability to focus on individual images, and digital archiving) have dramatically improved detection limit of incidental lesions. (Kara, 2018)

Magnetic resonance imaging (MRI) of the lumbar spine is frequently performed to evaluate patients with back pain. The images for reporting are commonly magnified around the vertebral column cropping out much of the structures within the lumbar. While this provides optimal delineation of spinal pathologies, it potentially results in the exclusion of important spinal pathologies from the final dataset. Given the simplicity of providing wide field of view reconstructions that encompass these structures. (Kevin, 2018)

We aimed to calculate the incidental findings and reporting rates and clinical importance of spinal findings that were incidentally detected on the magnetic resonance imaging (MRI) scans of lumbar spine.

1.2 Research problem:

There is some incidental associated problems unknown associate with back pain and here lies the importance of research to exclude these incidental problems helps to known it during MRI lumbar spine.

1.3 Hypothesis:

The early detection of the incidental finding helps the physician to treat the disease than the late detection of the disease

1.4 Objectives of the study:

1.4.1 General objective:

To study the incidental findings and reporting rates and clinical importance of spinal findings that were incidentally detected on the magnetic resonance imaging (MRI) scans of lumbar spine.

1.4.2 Specific objective:

- To demonstrate the types of incidental findings on lumbar MRI.
- To determine the distributions of the incidental findings and types of incidental findings according to gender.
- To determine the distributions of the incidental findings and types of incidental findings according age groups.

2 Research over view:

To make the aims of the project stated above true, the thesis falls into five Chapters: Chapter one, which is an introduction, deals with theoretical frame work of the study. It presents the statement of the of the study problems, objectives of the study, and thesis outcome chapter two, deals with theoretical background of lumber (anatomy, physiology and pathology), review of the instrumentations and techniques which include assessment by magnetic resonance imaging and literature review (previous studies). While chapter three discusses the material and method and chapter four include presentation of the results and finally Chapter five deals with the discussion, recommendations, conclusions of the study performed as well as future work.

Chapter Two

Theoretical Background and Previous Studies

Chapter Two

Theoretical Background and Previous Studies

2.1 Theoretical Background

2.1.1 Lumbar Spine Functional Anatomy and Physiology

2.1.1.1 Lumbar Vertebrae

The lumbar spine is formed by five vertebrae. The vertebrae are commonly referred to as L1 through L5. L1 is the most superior vertebra in the lumbar spine, and it abuts the thoracic spine, whereas L5 is the most inferior vertebra and abuts the sacral spine. The anterior or ventral element of each vertebra is called the vertebral body. The vertebral bodies of the middle and lower lumbar spine are more substantial in size to allow them to bear greater loading forces. Posterior, or dorsally, each vertebra has a bony arch that encircles the spinal canal. It is composed of two transverse processes, two sets of facet joints, two pedicles, two laminae, and one spinous process. The bony arch, also referred to as the posterior elements, is quite bulky. It provides the necessary support for upright posture (Fig 2-1). The non compromised spinal canal has ample room forthe cauda equina and for cerebrospinal fluid (CSF). (Choi , 2009).

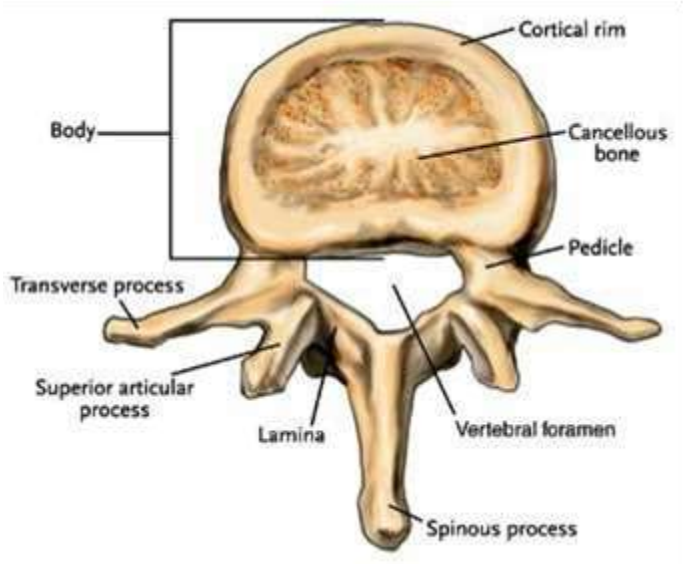


Figure (2.1): Lumbar vertebra (Chou et al,2009)

Facet joints (bilaterally) are composed of a superior articulating process and an inferior articulating process. The superior articulating process forms a joint with the inferior articulating process of the vertebra above (e.g., superior articulating processes of L3 forms two facet joints with the inferior articulating processes of L2). They have a loose capsule and asynovial lining; thus they are apophyseal joints (Fig 2-2).

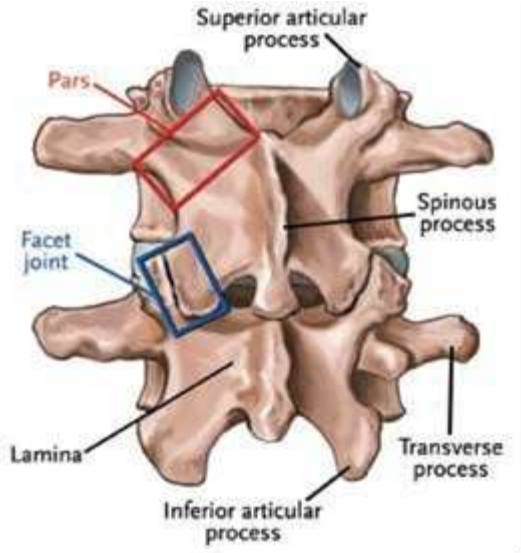
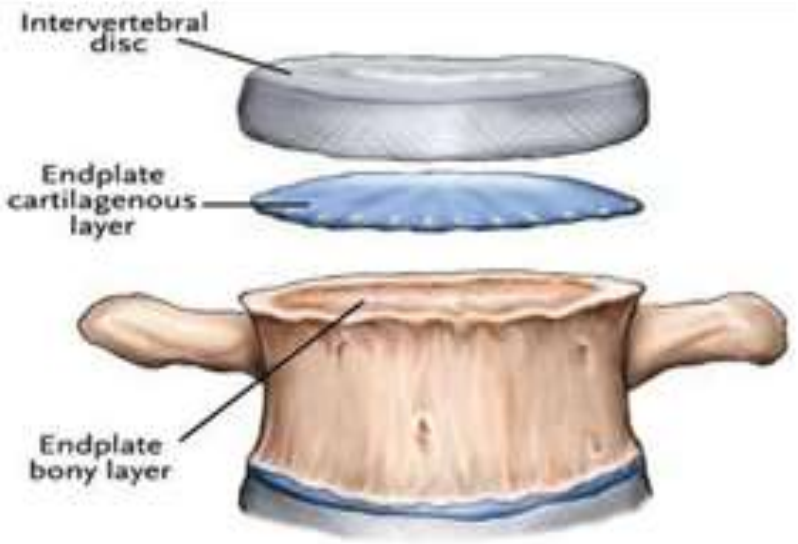


Figure (2.2): Lumbar spine: Posterior view (Parker &Son ,2011)

The nerve root canal, also called the lateral recess, is adjacent to the pedicles and facet joints in the region of the foramina. It encompasses the nerve root as it exits the spinal cord .The neural foramina, also referred to as the intervertebral foramina, is the actual far-lateral exit opening of the nerve root canal (Chou et al,2009). The lumbar vertebral, or spinal, canal is supported anteriorly by the posterior edge of the vertebral body as well as the posterior longitudinal ligament. This ligament lies on the posterior vertebral body surface. The lateral elements of the vertebral canal are the pedicles and the facet joints, with corresponding articular capsules. Posteriorly, the vertebral canal is formed by the laminae and ligamenta flava (Chou et al,2009).

2.1.1.2 Intervertebral Disc

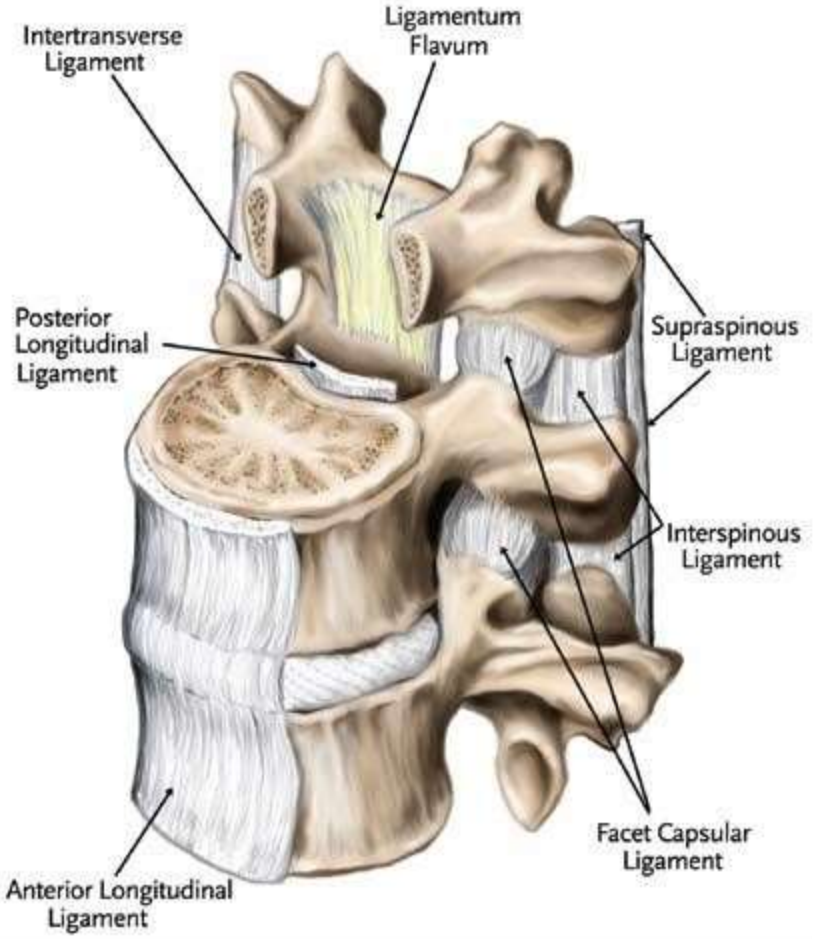
Each Intervertebral disc in the lumbar spine provides support and facilitates movement while resisting excessive movement. The disc permits slight anterior flexion, posterior extension, lateral flexion, rotation, and some circumduction (Shankar,Scarlett & Abraham, 2009). The disc is the largest a vascular structure in the body (Singh et al, 2009).It is composed of the nucleus pulposus and the annulus fibrosus. In someone less than 35 years old, the nucleus pulposusis soft, rather like crab meat in texture. With aging, the nucleus pulposus dehydrates. Surrounding the nucleus pulposus is the annulus fibrosus, which is tough and fibrous. The fibers of the annulus fibrosus are concentric, like the layers of a radial tire. The concentric arrangement provide great resistance and strength. Each disc is bonded to the vertebral body below and above it by a thin cartilaginous plate, referred to as the endplate (Fig 2-3). The endplate resists herniation of the disc into the vertebral body and gives the disc its shape (Hicks, Morone &Weiner 2009).



Figure(2.3): Intervertebral disc (Parker &Son 2011)

2.1.1.3 Ligaments

By the posterior longitudinal ligament. The laminae are connected by an elastic yellow ligament called the flavum. Each facet joint is connected to a capsular ligament. The transverse processes are connected by intertransverse ligaments. The rotator brevis and rotator longus ligaments connect the transverse processes to the laminae of the superior two vertebrae. The spinous processes are connected by the supraspinous and infracspinous ligaments (Fig 2-3), (Chou et al,2009).



Figure(2.4): Ligaments of the lumbar spine (Chou et al,2009)

2.1.1.4 Biomechanics

The functional unit of the spinal column is the motion segment. A motion segment is composed of two adjacent vertebrae, the disc between them, the facet joints connecting them, and the ligaments attached to the

vertebrae. The geometry and health of the functional units help a surgeon determine which patients will benefit from surgery, as well as the most appropriate surgical intervention for a given patient (McGill & Karpowicz 2009).

2.1.1.5 Spinal Cord

The spinal cord ends at approximately the L1–L2 level in an adult. The conus medullar is the end of the spinal cord. The filum terminale is an extension of the pia mater,which descends below the conus medullaris and is anchored to the coccyx(Shankar,Scarlett & Abraham 2009).

2.1.1.6 Nerve Roots

The cauda equina is a fanning bundle of lumbar and sacral nerve roots exiting off the spinal cord at the conus medullaris.This mass of nerve roots provides communication the lower extremities and controls bowel, bladder, and sexual function The cauda equina is relatively resistant to neurologic insults, compared with the spinal cord The exiting nerve root in the lumbar spine is numbered according to the pedicle above it. For instance, the L5 nerve root passes below the L5 pedicle(Shankar,Scarlett & Abraham 2009).

2.1.1.7 Vasculature

The abdominal aorta follows the left side of the spine until L4, where it bifurcates into the left and right common iliac arteries . The femoral arteries arise from the common iliac arteries. The middle sacral artery, iliolumbar artery, and internal iliac artery supply blood to L5 and the sacrum. Segmental arteries branch off the aorta and supply the vertebral body, posterior elements, and paraspinal muscles of the lumbar spine. Near the posterior wall of the vertebrae, each segmental artery bifurcates into a posterior branch and spinal branch. The spinal branch enters the vertebral canal through the intervertebral foramen and supplies portions of the posterior vertebral body. It joins other spinal branches at other

levels to form the anterior spinal artery. The anterior spinal artery supplies the anterior two-thirds of the spinal cord. Segmental veins drain into the inferior vena cava, which originates at the convergence of the left and right common iliac veins at the L4 level The inferiorvena cava terminates in the right atrium of the hear(Becske & Nelson ,2009).

2.1.2 Pathology of the lumber spine

Spinal neoplasm: Tumors of the spine are easily classified as extradural, intradural/extramedullary, and intramedullary. Regarding spinal tumors in general, extradural lesions occur most commonly and most are metastatic. Of the intradural lesions (which are rare), 84% are extramedullary, the majority being nerve sheath tumors or meningiomas. Approximately 16% of intradural tumors are intramedullary, the most common being ependymoma followed by astrocytoma.

A primary spinal tumor means it comes from cells within or near the spine. They can involve the spinal cord, nerve roots, and/or the vertebrae (bones of the spine) and pelvis. They can be benign (non-cancerous) or malignant (cancerous). In general, benign tumors do not invade other tissues. Malignant tumors may invade other tissues and organs in the body. Although primary spinal tumors often contain a number of abnormal genes their cause remains unknown. In some cases, the tumors run in families. Tumors in the spine become a problem when they compress the spinal cord or nerves. This can lead to serious complications such as paralysis and loss of bladder and bowel control. Others can destroy the vertebral bone that supports the spinal cord making it unstable (Jackson R et al 2000).

A secondary spinal tumor is more common. This means that the tumor traveled there from cancer somewhere else in the body. These secondary or metastasized tumors are always cancerous. These cancer cells travel and cause tumors that usually involve the vertebrae or bony portion of the

spine. They may come from melanoma (skin cancer), cancer in the lung, breast, prostate, kidney, or thyroid gland for example Malignant Spinal tumors (Jackson R et al 2000).

2.1.2.1 Multiple Myeloma

Myeloma is the most common primary malignant tumor of bone. It typically affects adults greater than 40 years of age. It tends to be generalized, involving multiple bones, but back pain and involvement of the spine is the most common presenting complaint. Treatment is palliative; meaning that disease can be controlled, but not completely cured. Chemotherapy is used to control the pain and slow the progression of the disease. Surgery may be required if pathological fractures develop or there is compression of the spinal cord. Cancer in the bone marrow is called multiple myeloma. Bone tissue is destroyed by excessive growth of plasma cells in the bone marrow. When X-rayed it appears that holes have been taken out of the bone. These are called osteolytic lesions. Plasma cells are part of the immune system and in multiple myeloma they grow uncontrolled forming tumors in the bone marrow. The spine is the most common site of involvement with multiple myeloma. Extradural compressive lesions are a well known complication of this disease (Legaye et al 1998).

2.1.2.2 Benign Spinal tumors

Osteoma: Osteoid osteoma is the most common of the benign tumors involving the bone of the spine. It is usually found during adolescence. It may be discovered because of scoliosis or curvature of the spine. It may cause pain that does not ease up, and is worse at night. Anti-inflammatory medications are used for treatment. Sometimes removal of the tumor by surgery is necessary. A newer, less invasive treatment is called radio-frequency ablation. These tumors rarely recur.

2.1.2.3 Osteoblastomas

Osteoblastomas are larger versions of osteoid osteomas. They tend to be found in people under the age of 30. They may cause scoliosis or curvature of the spine. Osteoblastomas tend to be more aggressive and require surgery to remove the tumor. There is a 10% chance that the tumor may recur.

2.1.2.4 Enchondromas&Osteochondroma

Enchondromas are tumors involving cartilage. They may grow into the spinal canal or press on the spinal nerve roots. When they cause paralysis, bowel or bladder incontinence, or other neurological symptoms they are surgically removed. They rarely can become chondrosarcomas, which are malignant tumors that can spread to other parts of the body. Osteochondroma is a slow growing tumor of the cartilage usually affecting adolescents. It is uncommon and is usually found in the posterior (rear) spine.

2.1.2.5 Hemangioma

Hemangiomas are tumors involving blood vessels that affect the vertebral body of a spinal segment. They are most commonly found in the thoracic or lumbar portion of the spine. They occur more frequently during mid-life. They are found more often in women than men. They can be a source of pain but often do not cause pain. They may be large enough to cause collapse of the vertebral body which could affect the spinal cord or nerve roots.

2.1.2.6 Spinal Inflammatory Disorders

Inflammatory disorders of the spine can be caused by a wide range of conditions, including arthritis, osteoporosis, and infection. Inflammation in the spine is rare but can be a significant source of pain and disability, especially if these hard-to-diagnose conditions go untreated (Bernhartdt M et al 2009).

2.1.2.6.1 Ankylosing spondylitis

Ankylosing spondylitis (AS) is an inflammatory condition that affects the joints in your spine. Spondylitis simply means inflammation of the spine. As part of the body's reaction to inflammation, calcium is laid down where the ligaments attach to the bones that make up the spine (vertebrae). This reduces the flexibility of your back and causes new bone to grow at the sides of the vertebrae. Eventually the individual bones of the spine may link up (fuse). This is called ankylosis and can be seen on x-rays. Ankylosing spondylitis typically starts in the joints between your spine and pelvis, but it may spread up your spine to your neck. It can sometimes affect other parts of the body, including your joints, tendons or eyes. Ankylosing spondylitis varies from person to person – your symptoms might be so mild that you can almost forget you have the condition, but if they're more serious it could have a big impact on your quality of life (Bernhartdt M et al 2009).

2.1.2.6.2 Arachnoiditis

Arachnoiditis describes a pain disorder caused by the inflammation of the arachnoid, one of the membranes that surround and protect the nerves of the spinal cord. The arachnoid can become inflamed because of an irritation from chemicals, infection from bacteria or viruses, as the result of direct injury to the spine, chronic compression of spinal nerves, or complications from spinal surgery or other invasive spinal procedures. Inflammation can sometimes lead to the formation of scar tissue and adhesions, which cause the spinal nerves to "stick" together. If arachnoiditis begins to interfere with the function of one or more of these nerves, it can cause a number of symptoms, including numbness, tingling, and a characteristic stinging and burning pain in the lower back or legs. Some people with arachnoiditis will have debilitating muscle cramps, twitches, or spasms. It may also affect bladder, bowel, and sexual function. In severe cases, arachnoiditis may cause paralysis of the lower limbs.

2.1.2.6.3 Discitis:

Is an inflammation of the vertebral disk space often related to infection. Infection of the disk space must be considered with vertebral osteomyelitis; these conditions are almost always present together, and they share much of the same pathophysiology, symptoms, and treatment. Although Discitis and associated vertebral osteomyelitis are uncommon conditions, they are often the causes of debilitating neurologic injury. Unfortunately, morbidity can be exacerbated by a delay in diagnosis and treatment of this condition. The lumbar region is most commonly affected, followed by the cervical spine and, lastly, the thoracic spine.

2.1.2.6.4 Congenital spinal anomalies:

Asomia (A genesis): Complete absence of the body of a vertebra may occur despite the presence of the posterior elements (Figure 2). This anomaly nesuIts from failure of ossification centers of the body to appear. One on more vertebral segments may be involved.Hemi-vertebra Unilateral wedge vertebra is due to lack of ossification of one-half of the body. A right on left hemi-vertebra may thus occur. The hemi-vertebra assumes a wedge-shaped configuration with the apex of the wedge reaching the midplane. Scoliosis is often present at birth. Dorsal and ventral hemi-vertebrae occur because of failure of the ventral or dorsal half of the vertebral body to ossify. The failure of ossification is believed to be secondary to ischemia during the developmental stage. A kyphotic deformity is seen at the site of a dorsal hemivertebra. A ventral hemivertebra is extremely rare and results from failure of ossification of the dorsal half of the vertebral body. Hemivertebra secondary to hemimetametric segmental displacement or persistence of the night and left halves of the vertebral body leads to the hemiventebnae being separated from each other in the sagittal plane. One such hemivertebra may fuse with the body of a yentebnal segment above or below the affected segment

2.1.2.6.5 Coronal clefts:

This anomaly results from a failure of fusion of the anterior and posterior ossification centens which remain separated by a cartilage plate. It

represents a delay in normal vertebral maturation; in most cases clefts disappear by six months after birth. Coronal clefts are usually seen in the lower thonacic on lumbar vertebral bodies. The deformity is most often seen in premature male infants and can be recognized in utero. Cleft vertebrae may also occur in infants with chondrodystrophia calcificanscongenita. Radiographically, a vertical radiolucent band is seen just behind the midportion of the body on the latenial view of the spine.

Butterfly Vertebra (Sagittal Cleft Vertebra)Butterfly vertebrae result from the failure of fusion of the lateral halves of the vertebral body because of persistent notochondal tissue between them. The involved vertebral body is widened, and the bodies above and below the butterfly vertebra adapt to the altered intervertebral discs on either side by showing concavities along the adjacent end plates. Some bone bridging may occur across the defect which is usually seen in the thoracic on lumbar segments of the spine. Anterior spina bifida, with on without anterior meninogocele, may be associated with a butterfly vertebra.The intervertebral fonamma of block vertebrae become ovoid and narrowed. Congenital vertebral fusion usually occurs in the lumbar and cervical segments.Abnormal Size: An abnormality in the size of a vertebra is most often due to a compression deformity of the body. Certain diseases, however, may affect the normal vertebral growth resulting in altened size.

Small Vertebral Body: Radiation-induced vertebral hypoplasia may result from irradiation of the spine during early childhood (Figure 10). The effect is dose dependent and, in general, does not occur with doses of less than 1000 rads. Unilateral radiation may cause scoliosis because of unequal growth of the affected bodies, the concavity of the scoliosis occurring on the irradiated side. Osteoporosis and vertebral collapse may be seen in adults following irradiation.

2.1.3 Methods of lumber spine imaging

2.1.3.1Magnetic Resonance Imaging:

2.1.3.1.1.MRI physics:

Magnetic resonance imaging (MRI) is a medical imaging procedure that uses strong magnetic fields and radio waves to produce cross-sectional images of organs and internal structures in the body. Because the signal detected by an MRI machine varies depending on the water content and local magnetic properties of a particular area of the body, different tissues or substances can be distinguished from one another in the study image.MRI can give different information about structures in the body than can be obtained using a standard x-ray, ultrasound, or computed tomography (CT) exam. an MRI exam of a joint can provide detailed images of ligaments and cartilage, which are not visible using other study types. In some cases, a magnetically active material (called a contrast agent) is used to show internal structures or abnormalities more clearly.(Pooely,2005).

Many MR systems are commercially available, each possessing different features and capabilities that are often difficult to evaluate and compare objectively. Many of these features are based on the operating software provided by the manufacturer,but certain hardware components are common to all systems. The major components are the computer and image processing systems, a magnet system, a gradient system, a radiofrequency system, and a data acquisition systems (Pooely,2005).

In most MRI devices, an electric current is passed through coiled wires to create a temporary magnetic field around a patient’s body. (In open-MRI devices, permanent magnets are used.) Radio waves are sent from and received by atransmitter/receiver in the machine, and these signals are used to produce digital images of the area of interest. Using MRI scans, physicians can diagnose or monitor treatments for a variety of medical

conditions, including: Abnormalities of the brain and spinal cord, Tumors, cysts, and other abnormalities in various parts of the body, Injuries or abnormalities of the joints ,Certain types of heart problems, Diseases of the liver and other abdominal organs, Causes of pelvic pain in women, Suspected uterine abnormalities in women undergoing evaluation for infertility .

MRI does not use ionizing radiation. There are no known harmful side-effects associated with temporary exposure to the strong magnetic field used by MRI scanners. There are important safety concerns to consider before performing or undergoing an MRI scan: The magnet may cause pacemakers, artificial limbs, and other implanted medical devices that contain metal to malfunction or heat up during the exam, Any loose metal object may cause damage or injury if it gets pulled toward the magnet, If a contrast agent is used, there is a slight risk of an allergic reaction. MRI contrast agents can cause problems in patients with significant kidney disease, Dyes from tattoos or tattooed eyeliner can cause skin or eye irritation, Medication patches can cause a skin burn, The wire leads used to monitor an electrocardiogram (ECG) trace or respiration during a scan must be placed carefully to avoid causing a skin burn and Prolonged exposure to radio waves during the scan could lead to slight warming of the body (Pooely,2005).

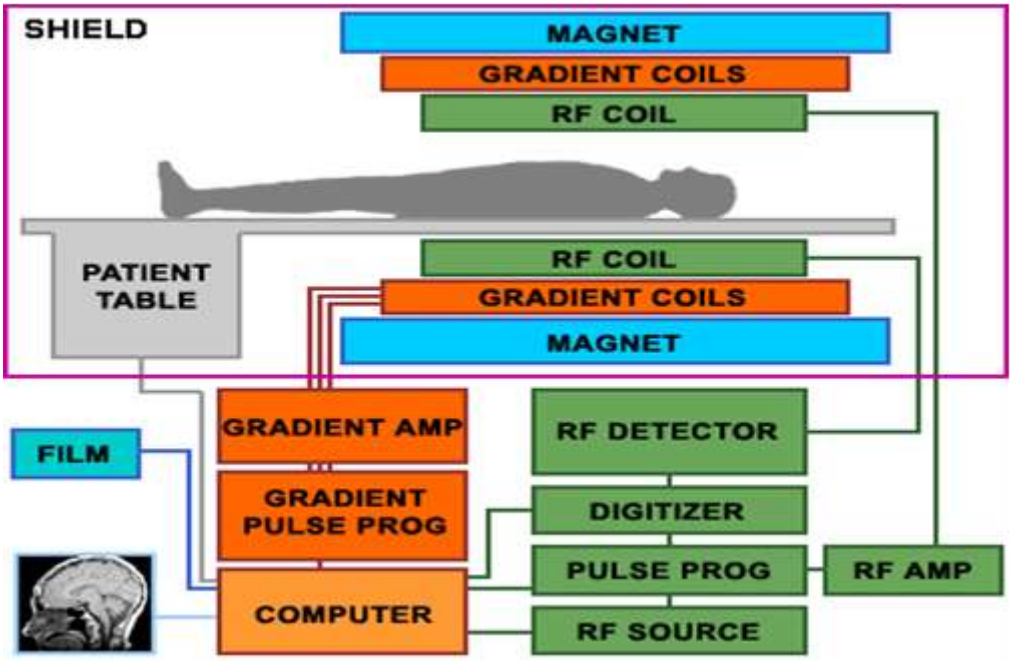


Figure 2-4.MRI schematic diagram (Pooely, 2005)

MRI is widely used now to visualize the spinal column and its contents. T1- and T2-weighted images give information about morphology and integrity of discs and vertebrae, the intervertebral foramina and facet joints, and an outline ofthe spinal cord. The vertebrae have a low-signal outer rim surrounding the high-signal cancellous bone. The basivertebral veins are seen in the posterior midline of the vertebral body.(Malcolm ,2002)

A very simplified pulse sequence is a combination of RF pulses, signals and intervening periods of recovery.TR and TE. A pulse sequence consists of several time periods: The repetition time (TR)is the ti me from the application of one RF pulse to the application of the next RF pulse for each slice and is measured in milliseconds (ms). The TR determines the amount of longitudinal relaxation that is allowed to occur between the end of one RF pulse and the application of the next. TR thus determines the amount of T1 relaxation that has occurred when the signal is read.The echo time (TE)is the ti me from the application of the RF pulse to the

peak of the signal induced in the coil and is also measured in (ms). The TE determines how much decay of transverse magnetization is allowed to occur. TE thus controls the amount of T2 relaxation that has occurred when the signal is read. (Catherine Westbrook, etal –2011)

To demonstrate either T1, proton density or T2 contrast, specific values of TR and TE are selected for a given pulse sequence. The selection of appropriate TR and TE weights an image so that one contrast mechanism predominates over the other two.A T1 weighted image is one where the contrast depends predominantly on the differences in the T1 times between fat and water (and all the tissues with intermediate signal). Because the TR controls how far each vector recovers before the slice is excited by the next RF pulse, to achieve T1 weighting the TR must be short enough so that neither fat nor water has sufficient ti me to fully return to B 0. If the TR is too long, both fat and water return to B 0 and recover their longitudinal Magnetization fully. When this occurs, T1 relaxation is complete in both tissues and the differences in their T1 times are not demonstrated.TR controls the amount of T1 weighting.F or T1 weighting the TR must be short. (Catherine Westbrook, e tal –2011)

A T2 weighted image is one where the contrast predominantly depends on the differences in the T2 times between fat and water (and all the tissues with intermediate signal). The TE controls the amount of T2 decay that is allowed to occur before the signal is received. To achieve T2 weighting, the TE must be long enough to give both fat and water ti me to decay. If the TE is too short, neither fat nor water has had ti me to decay, and therefore the differences in their T2 times are not demonstrated.TE controls the amount of T2 weighting.F or T2 weighting the TE must be long. (Catherine Westbrook, etal –2011)

A proton density image is one where the difference in the numbers of mobile hydrogen protons per unit volume in the patient is the main

determining factor in forming image contrast. Proton density weighting is always present to some extent. To achieve proton density weighting, the effects of T1and T2 contrast must be diminished so that proton density weighting can dominate. A long TR allows both fat and water to fully recover their longitudinal magnetization and so diminishes T1weighti ng. A short TE does not give fat or water ti me to decay and so diminishes T2 weighting. In any image, the contrast due to the inherent proton density together with T1 and T2 mechanismsoccur simultaneously and contribute to image contrast. To weight an image so that oneprocess is dominant, the other processes must be diminished. (Catherine Westbrook, etal –2011)

2-1-3-1-2.MRI Technique:

2-1-3-1-2-1.Patient Positioning:

The patient lies supine on the examination couch with their knees elevated over a foam pad, for comfort and to flatten the lumbar curve so that the spine lies nearer to the coil. The coil should extend from the xiphister- num to the bottom of the sacrum for adequate coverage of the lumbar region. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes just below the lower costal margin, which corresponds to the third lumbar vertebra.(Catherine Westbrook. – 2008)

2-1-3-1-2-2.Suggested Protocol:

-Sagittal/coronal SE/FSE T1 or coherent GRE T2* Acts as a localizer if three-plane localization is unavailable.

-Sagittal SE/FSE T1

-Sagittal SE/FSE T2 or coherent GRE T2*

-Axial/oblique SE/FSE T1/T2 or coherent GRE T2* (Catherine Westbrook. – 2008)

2-1-3-1-2-3. Additional Sequences:

-Axial/oblique or Sagittal SE/FSE T1 With contrast for determining disc prolapse versus scar tissue in failed back syndrome, and for some tumours.

-Coronal SE/FSE T1 For cord tethering or alternative view of conus when sagittals are inconclusive.

-Axial/oblique FSE T2 For arachnoiditis. (Catherine Westbrook. –2008)

2-1-3-1-3. Patient Considerations:

Many patients are in severe pain especially if they are suffering from a prolapsed lumbar disc. Make the patient as comfortable as possible with pads supporting their knees in a slightly flexed position. Small pads placed in the lumbar curve often help to alleviate sciatica and other types of back pain. Due to excessively loud gradient noise associated with some sequences, ear plugs must always be provided to prevent hearing impairment. (Catherine Westbrook. – 2008)

2-1-3-1-4. Contrast Usage:

Contrast is used to distinguish disc prolapse from scar tissue post-operatively in failed back syndrome.Contrast is also invaluable to visualize suspicious lesions in the conus. (Catherine Westbrook. – 2008).

2-1-3-2 conventional x-ray

X-rays are a form of radiation, like light or radio waves, that are focused into a beam, much like a flashlight beam. X-rays can pass through most objects, including the human body. X-rays make a picture by striking a detector that either exposes a film or sends the picture to a computer. Dense tissues in the body, such as bones, block (absorb) many of the X-rays and look white on an X-ray picture. Less dense tissues, such as muscles and organs, block fewer of the X-rays (more of the X-rays pass through) and look like shades of gray on an X-ray. X-rays that pass only

through air, such as through the lungs, look black on the picture (Michael F et al 2008).

Spinal X-rays are pictures of the spine. They may be taken to find injuries or diseases that affect the discs or joints in your spine. These problems may include spinal fractures, infections, dislocations, tumors, bone spurs, or disc disease. Spinal X-rays are also done to check the curve of your spine (scoliosis) or for spinal defects.

2.1.3.3 Computed Tomography:

Computed tomography (CT scan or CAT scan) is a noninvasive diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce horizontal, or axial, images (often called slices) of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat, and organs. CT scans are more detailed than standard X-rays.

Computed tomography (CT) of the spine is a diagnostic imaging test used to help diagnose—or rule out—spinal column damage in injured patients. CT scanning is fast, painless, noninvasive and accurate. In emergency cases, it can reveal internal injuries and bleeding quickly enough to help save lives. A CT scan of the spine may be performed to assess the spine for a herniated disk, tumors and other lesions, the extent of injuries, structural anomalies such as spina bifida (a type of congenital defect of the spine), blood vessel malformations, or other conditions, particularly when another type of examination, such as X-rays or physical examination, is not conclusive. CT of the spine may also be used to evaluate the effects of treatment of the spine, such as surgery or other therapy (Michael F et al 2008).

2.1.3.4 Nuclear Medicine:

Nuclear medicine examinations hold an important position in the diagnosis of diseases of the spine. During the last decade, decisive progress has been made in the field of instrumentation and radiopharmaceutical techniques: the use of high-resolution collimators and the introduction of emission computer tomography as examples of improved instrumentation as well as 99m-Technetium red blood cell labelling as a new radiopharmaceutical technique. These present some of the developments responsible for the growing importance of scintigraphical diagnosis. Inflammatory processes of the vertebrae and the surrounding soft tissues can be detected or excluded with high reliability by the use of radionuclide-labelled granulocytes. The important role of bone scintigraphy in the differential diagnosis of neoplastic bone disease relies on its high sensitivity combined with the quantitative analysis of increased bone metabolism. Furthermore, it provides exact information about the extent and a possible metastatic spread of bone tumours. In the field of orthopaedy and surgery, skeletal scintigraphy is of growing importance as a highly sensitive procedure in the detection of special traumatic lesions such as acute vertebral compression fractures and in the follow-up of patients after bone surgical interventions. Despite the progress of other imaging modalities such as computer tomography and magnetic resonance imaging, nuclear medicine today is well-established in the assessment of diseases of the vertebral column. Among all scintigraphical diagnostic procedures, bone scintigraphy and the different techniques of inflammation imaging are of special importance.

2.2 Previous Studies:

Study by: Hee-Jin Park, Yong-Hwan Jeon, Myung-Ho Rho, Eun-Ja Lee, Noh-Hyuck Park, Joon-Hee Jo and Sung-Il Park 2010

The aim of the study was to evaluate the frequency and types of incidental findings of the lumbar spine during MR evaluation for herniated intervertebral disk disease. A total of 1268 patients (male-to-female ratio, 421:847; age range, 1–97 years) with clinically suspected herniated intervertebral disk disease underwent MRI of the lumbar spine. Musculoskeletal radiologists evaluated the MR examinations for the presence of incidental findings. We defined incidental finding as any abnormal finding not related to the chief complaint. Vertebral hemangioma, Tarlov cyst, fibrolipoma, synovial cyst, and sacral meningocele were included. Frequency distributions of the assessed imaging characteristics were calculated. For analysis of the relationship of incidental findings with patient characteristics, the chi-square test was used.

Results Overall, 107 patients (8.4%) had incidental findings. Fibrolipoma was most common (41 cases, 3.2%), followed by Tarlov cyst (27 cases, 2.1%) and vertebral hemangioma (19 cases, 1.5%). Fibrolipoma and sacral meningocele were more common in males ($p <$

0.05). There was no difference in the incidence between the sexes in the other incidental findings ($p = 0.26–0.96$). Four of the five incidental findings were significantly more frequent in individuals younger than 50 years ($p < 0.05$), whereas the incidence of vertebral hemangioma did not differ by patient age ($p = 0.32$).

Incidental findings at MRI of the lumbar spine were common and associated with age and sex. Most were benign findings. An awareness of the prevalence of the incidental findings detected at MRI of the lumbar spine is helpful for diagnosing lesions not related to symptoms.

Study by: Mogahid M.A. Zidan, Ikhlas A. Hassan, Abdelrahaman M. Elnour, Wadah M. Ali, Mustafa Z. Mahmoud, Batil Alonazi, Abbas Khalid, and Salah Alib. 2018

The aim of the study was to calculate the frequencies of incidental extraspinal findings and incidentally detected congenital anomalies or anatomical differences in the lumbar spine on magnetic resonance imaging (MRI) scans of intervertebral discs. A total of 379 lumbar spine MRI cases were prospectively investigated in the period spanning from August 2016 to January 2018. Both 2 and 0.35 Tesla MRI units (Toshiba and Siemens Medical Systems) were used to examine patients with clinically suspected intervertebral disc abnormalities at three MRI diagnostic centers in Khartoum State, Sudan.

Results of the 379(100%) patients, 90(23.7%) patients were presented with incidental findings. Among the incidental findings, 39(10.3%) were renal cysts, 10(2.6%) were retroverted uteri, 5(1.3%) were Nabothian cysts, 4(1.1%) were ovarian cysts, 10(2.6%) were uterine fibroids, 3(0.8%) were endometrial thickening, 11(2.9%) were indicative of hydronephrosis, 4(1.1%) were uncovered prostatic enlargement, 2(0.5%) were atrophic kidney, and 1(0.3%) each was of an ectopic kidney and bladder wall thickening, respectively.

Study by: Sedat Alpaslan Tuncel, Bekir Çaglı, Aslan Tekatas¸, Mehmet Yadigar Kırıcı, Ercüment Ünlü, Hakan Gençhellaç. 2015

The aim of the present study was to determine the prevalence and reporting rate of incidental findings (IF) in adult outpatients undergoing lumbar magnetic resonance imaging (MRI). Re-evaluation of a total of 1278 lumbar MRI images (collected from patients with a mean age of 50.5 years, range 16–91 years) captured between August 2010–August 2011 was done by a neuroradiologist and a musculoskeletal radiologist. IFs were classified according to organ or system (liver,

gallbladder, kidney, bladder, uterus, ovary, lymph node, intestine and aorta). The rate of reporting of a range of IF was examined. The outcome of each patient's treatment was evaluated based on review of hospital records and by telephone interviews.

Results A total of 253 IFs were found in 241 patients (18.8% of 1278). Among these, clinically significant IFs (n = 34) included: 2 renal masses (0.15%), 2 aortic aneurysms (0.15%), 2 cases of hydronephrosis (0.15%), 11 adrenal masses (0.86%), 7 lymphadenopathies (0.55%), 6 cases of endometrial or cervical thickening (0.47%), 1 liver hemangioma (0.08%), 1 pelvic fluid (0.08%) and 2 ovarian dermoid cysts (0.15%). Overall, 28% (71/253) of IFs were included in the clinical reports, while clinically significant findings were reported in 41% (14/34) of cases.

Study by: Odile Fernande Zeh1, Emilienne Guegang Goujou1, Armel Philippe Awana, Julienne Onguene Medza, Joshua Tambe, Claude Sandra Raïssa Abomo Ngodo1, Maxwell Goudjou Sandjong1, Joseph Gonsu Fotsin. 2017

The aim of the study was to assess the importance of incidental extraspinal findings on Magnetic Resonance Imaging of the lumbar spine in two hospital facilities. It was a descriptive and retrospective study from November 2015 to March 2016. The records of patients who had done a Magnetic Resonance Imaging (MRI) scan of the lumbar spine were re-read in search of incidental findings. The incidental findings found were classified using Colonography Reporting and Data System(C-RADS) classification of extracolonic lesions to assess clinical significance. The prevalence of incidental findings was calculated for each facility, as well as the distribution according to age, the organs involved and the clinical importance. A non-

detection rate was calculated by confronting the findings of the study with the original re-ports.

Results the prevalence of incidental findings was respectively 33% (19 out of 36) in Jordan Medical Center (JMC) in Yaounde and27.74% (106 out of 292) in Jacques Monod Hospital. The extraspinal incidental findings were classified mainly as extracolonic 2 (E2): 58% in each facility. The percentage detection of incidental findings was 5% at JMS and 1.7% at Jacques Monod Hospital.

Chapter Three

Materials and Methods

Chapter Three

Materials and methods

3.1 Materials

3.1.1 Design of the study

This was a prospective analytical study where the data collected prospectively.

3.1.2 Population and Duration of the study

The study population included 22 males and 28 females their age (25-85years), who underwent imaging between February 2018 to February 2019.

3.1.3 Area of the study

The study was performed in Yastabshiroon medical center in Omdurman.

3.1.4 Inclusion criteria

Most of the patients came to the hospital with clinically chronic back pain.

3.1.5 Exclusion criteria

Patient with a history of acute trauma.

3.1.6 Data collection

Data collected by special data collection sheet.

3.1.7 Machine used

MRI examinations were performed on a 0.2 T magnet GE – health care using the body coil and fast spinecho imaging.

Figure 3.1: Machine used

3.2 methods

3.2.1 Positioning

The patient lies supine on couch with their knees elevated over a foam pad, and feed first.

This retrospective study was approved by the institutional ethics review board.

There was no requirement for informed patient consent.

3.2.2 Protocols

T_1 and T_2 weighted images were obtained in the sagittal plane and T_2 in the axial plane, and the contrast were add if needed for sagittal imaging, a field of view of 34cm and slice thickness of 5mm were used, for axial imaging a field of view of 27cm, and slice thickness of 6mm were used.

The following MR sequence were performed in sagittal plan, T_1 weighted TR 620, TE 127, in axial planT_2 weighted TR 3600, TE 119.

3.2.3 Data Analysis

The data was analyzed using SPSS.

3.2.4 Data management

The data presented by tables and figures.

3.2.5 Ethical consideration

Ethical clearance had obtained from the authorities; no individual patient details mentioned throughout this study.

Chapter Four

Results

Chapter Four

Results

Table 4.1: distribution of participants according to gender:

Gender	Frequency	Percent
Male	22	44.0
Female	28	56.0
Total	**50**	**100.0**

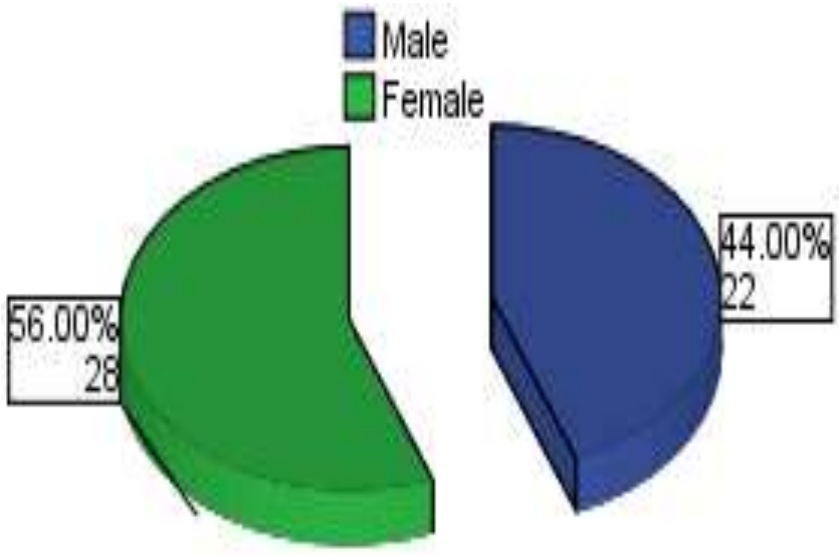


Figure (4.1): distribution of participants according to gender

Table 4.2: distribution of participants according to age:

Age	Frequency	Percent
25-35 years	5	10.0
36-45 years	9	18.0
46-55 years	11	22.0
56-65 years	10	20.0
More than 65 years	15	30.0
Total	**50**	**100.0**

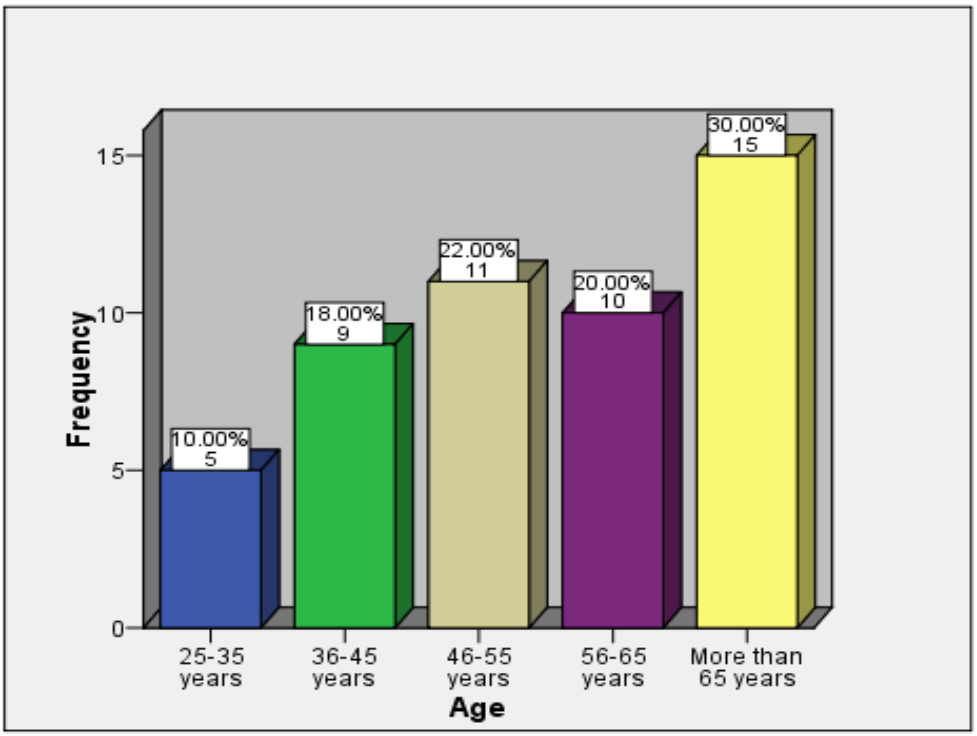


Figure (4.2): Participants distribution with respect to age

Table 4.3: distribution of participants according to diagnoses:

Diagnoses	Frequency	Percent
Lesion	2	4.0
Traumatic collapse	5	10.0
Secondary collapse	9	18.0
Hemangioma	18	36.0
Abscess	15	30.0
Cyst	1	2.0
Total	**50**	**100.0**

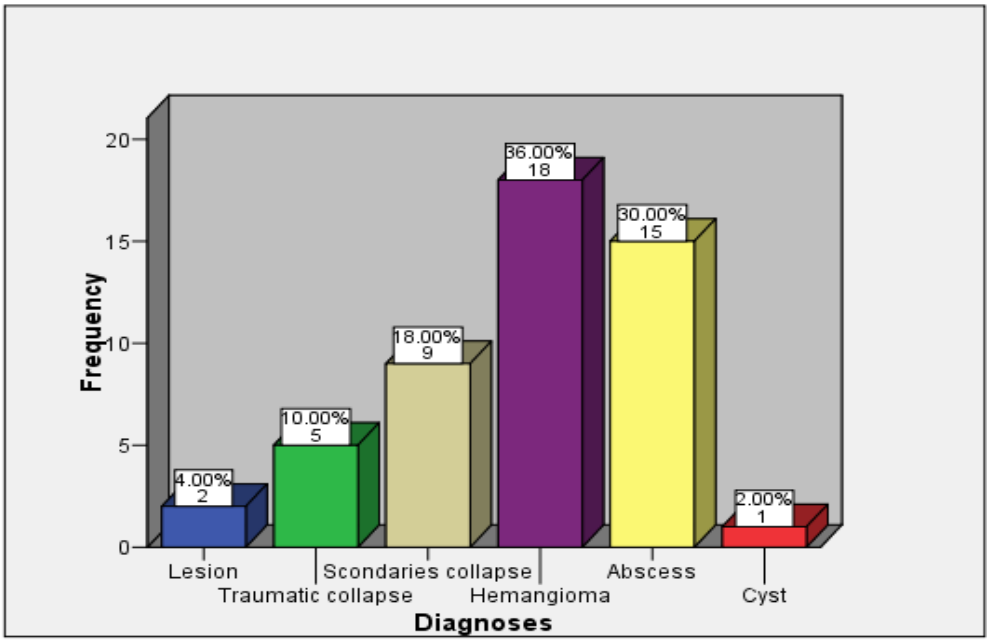


Figure (4.3): Participants distribution with respect to diagnoses

Table (4.4): Chi-square test for association of diagnoses and gender:

		Diagnoses						
Gender		Lesion	Traumatic collapse	Secondary collapse	Hemangioma	Abscess	Cyst	**Total**
Male	Count	1	2	5	5	9	0	**22**
	%	50.0%	40.0%	55.6%	27.8%	60.0%	.0%	**44.0%**
Female	Count	1	3	4	13	6	1	**28**
	%	50.0%	60.0%	44.4%	72.2%	40.0%	100.0%	**56.0%**
Total	**Count**	**2**	**5**	**9**	**18**	**15**	**1**	**50**
	%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Chi-Square Tests								
				Value	df	Sig. (2-sided)		
Likelihood Ratio				5.264	5	0.384		

Table (4.5): Chi-square test for association of diagnoses and age:

		Diagnoses						
Age		Lesion	Traumatic collapse	Secondary collapse	Hemangioma	Abscess	Cyst	**Total**
25-35 years	Count	0	0	1	2	2	0	**5**
	%	.0%	.0%	11.1%	11.1%	13.3%	.0%	**10.0%**
36-45 years	Count	0	0	1	6	1	1	**9**
	%	.0%	.0%	11.1%	33.3%	6.7%	100.0%	**18.0%**
46-55 years	Count	2	2	1	4	2	0	**11**
	%	100.0%	40.0%	11.1%	22.2%	13.3%	.0%	**22.0%**
56-65 years	Count	0	0	1	2	7	0	**10**
	%	.0%	.0%	11.1%	11.1%	46.7%	.0%	**20.0%**
More than 65 years	Count	0	3	5	4	3	0	**15**
	%	.0%	60.0%	55.6%	22.2%	20.0%	.0%	**30.0%**
Total	**Count**	**2**	**5**	**9**	**18**	**15**	**1**	**50**
	%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Chi-Square Tests								
				Value	df	Sig. (2-sided)		
Likelihood Ratio				28.637	20	0.095		

Chapter five
Discussion and Conclusion and Recommendation

Chapter five
Discussion and Conclusion and Recommendation

5.1 Discussion

This was a prospective analytical study to detect the incidental findings and reporting rates and clinical importance of spinal findings that were incidentally detected on the magnetic resonance imaging (MRI) scans of lumbar spine, involved 50 patients (22 males, 28 females) carried out at period between February 2018 and February 2019 in Yastabshiroon medical center in Omdurman.

The result shown from table (4.1) and figure (4.1) show that most (56%) of participants were females, since (44%) of them were males. Table (4.2) and figure (4.2) show that (30%) of participants were more than 65 years old, since (22%) of them were 46-55 years and (20%) of them were 56-65 years, while (18%) of them were 36-45 years, whereas only (10%) were 25-35 years old. Therefore, most of the participants were more than 45 years old. Table (4.3) and figure (4.3) show that the diagnoses for (36%) of participants was hemangioma, since for (30%) of them was abscess, while for (18%) of them was secondary collapse and for (10%) of them was traumatic collapse, whereas for only (4%) of them was lesions and for only (2%) of them was cyst, similar to Zidan et al and Tuncel et al studies.

From table (4.4) above, that the probability of the chi-square test statistic (chi-square =5.264) was (Sig. = 0.384), which is greater than the level of significance of 0.05. Thus, hypothesis that differences in “diagnoses” are related to gender is not supported and a diagnosis does not dependent on gender, similar to Zidan et.al study.

From the table (4.5) above, that the probability of the chi-square test statistic (chi-square =28.637) was (Sig. = 0.095), which is greater than the level of significance of 0.05. Thus, hypothesis that differences in “diagnoses” are related to age is not supported and diagnoses does not dependent on age similar to Tuncel et al study.

5.2 Conclusion

Incidental findings were common on routine MRI of the lumbar spine, most were benign and awareness of the prevalence of the incidental findings detected at MRI of the lumbar spine is helpful for diagnosing lesions not related to symptoms.

5.3 Recommendations

- Recommend further radiological investigation in all cases.
- Future studies should be done with several body characteristic in correlation with incidental finding, and use large sample size to improve statistical information and more accurate results.
- Researcher suggests that doing the same studies for all patients complaining of lower back pain to exclude major causes of lower back pain.

References

Kara O'Donnell, Gerald Quan, Anthony Upton. 2018. Extraosseous vertebral body haemangioma. Interdisciplinary Neurosurgery 12, 41-44.

Kevin T. Huang, Malia McAvoy, Jeffrey Helgager, Viren Vasudeva, John H. Chi. 2018. Spinal hemangioma mimicking a dumbbell-shaped schwannoma: Case report and review of the literature. Journal of Clinical Neuroscience 50, 160-162.

Molly Baker, Machelle Wilson, Stacey Wallach. 2018. Urogenital symptoms in women with Tarlov cysts. Journal of Obstetrics and Gynaecology Research 15. .

Pawin Gajaseni, Luca Labianca, Iara Lacerda, Stuart Weinstein. 2017. A Child with a Rare Extraosseous Extension and Pathologic Fracture from a Vertebral Hemangioma. JBJS Case Connector 7:4, e86.

Rishi Mugesh Kanna, Younis Kamal, Anupama Mahesh, Prakash Venugopal, Ajoy Prasad Shetty, S. Rajasekaran. 2017. The impact of routine whole spine MRI screening in the evaluation of spinal degenerative diseases. European Spine Journal 26:8, 1993-1998.

Stein J. Janssen, Paul T. Ogink, Joseph H. Schwab. 2018. The Prevalence of Incidental and Symptomatic Lumbar Synovial Facet Cysts. Clinical Spine Surgery 31:5, E296-E301.

Stephanie Bernard, Eric Walker, Meera Raghavan. 2017. An Approach to the Evaluation of Incidentally Identified Bone Lesions Encountered on Imaging Studies. American Journal of Roentgenology 208:5, 960-970.

Valeria Romeo, Carlo Cavaliere, Carmine Sorrentino, Andrea Ponsiglione, Lorenzo Ugga, Luigi Barbuto, Francesco Verde, Mario Covello. 2018. Clinical impact of coronal-STIR sequence in a routine lumbar spine MR imaging protocol to investigate low back pain. Medicine 97:23, e10789.

Wagner SC, Morrison WB, Carrino JA, Schweitzer ME, Nothnagel H. Picture archiving and communication system: effect on reporting of incidental findings. Radiology. 2002;225(2):500-5.

Yap KK, Ramaseshan G, Sutherland T, Shafik-Eid R, Taubman K, Schlicht S. Prevalence of incidental or unexpected findings on low-dose CT performed during routine SPECT/CT nuclear medicine studies. Journal of medical imaging and radiation oncology. 2015;59(1):26-33.

Yasuyoshi Miyao, Manabu Sasaki, Masanori Aoki, Masao Umegaki, Nobumitsu Shimada. 2018. Long-term Surgical Outcomes of Symptomatic Perineural (Tarlov) Cysts with Occlusion of the Cyst Orifice Using Autologous Fat Tissue. Spinal Surgery 32:1, 56-60.

Ying Huang, Tong Zhu, Hongyi Lin, Jing Li, Tao Zeng, Jian Lin. 2018. Symptomatic Tarlov Cysts: Surgical Treatment by Subcutaneous Infusion Port. World Neurosurgery 113, e722-e726.

Appendices

Appendix 1

Incidental Findings on Routine MRI Examination of Lumbar Spine

No	Name	Age	Sex	Findings

Appendix 2

Image 1: 27-year-old man with vertebral hemangioma. Sagittal T2-weighted image shows vertebral hemangioma (arrow) in second lumbar vertebral body.

Image 2: 22-year-old man with synovial cyst. Axial T2-weighted images show synovial cyst (arrow) adjacent to right facet joint.