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CORRELATION OF BODY MASS INDEX, AGE AND GENDER WITH THE DEGREE OF SPONDYLOLISTHESIS ON LUMBOSACRAL XRAY PHOTOS AT HAJI ADAM MALIK HOSPITAL MEDAN

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Abstract

Introduction :*Spondylolisthesis is a displacement of one vertebra relative to the vertebra below it with an estimated prevalence of spondylolisthesis of 6 to 7% at age 19 years, and up to 18% of adult patients undergoing MRI of the lumbar spine. Grade I spondylolisthesis accounts for 75% of all cases. Various factors can influence the occurrence of spondylolisthesis such as BMI, age and gender.* ***Objective****. This study aims to determine the characteristics and analysis of the relationship between spondylolisthesis patients and lumbosacral x-rays based on body mass index, age and gender as well as the local anatomical distribution and frequency of spondylolisthesis degrees.* ***Results :****A total of 120 patients were predominantly aged≥60 years old, female and obese. Based on the location of spondylolisthesis, most of them are at L4-5. There are almost the same numbers of scoliosis patients and those without scoliosis. The majority of spondylolisthesis patients are dominated by spondylosis on lumbosacral xray examination. There was a relationship between spondylolisthesis and age, BMI and gender (p<0.05). Spondylolisthesis patients with female risk factors are at risk of experiencing spondylolisthesis (OR=6.490) and obese patients are at risk of experiencing spondylolisthesis (OR=4.024).* ***Discussion:****The prevalence of spondylolisthesis and patient gender may be related to the influence of the female sex hormone estrogen on tissues associated with the human musculoskeletal system. An increase in body mass index (BMI), an axial load on the intervertebral discs and facet joints, causes an increase in compressive forces on the spine. Age has the potential to be a determining factor in degenerative conditions with the occurrence of disc narrowing, osteoarthritis (OA) of facet joints, and degenerative spondylolisthesis showing a significant linear trend.* ***Conclusion :****There is a significant relationship between spondylolisthesis and BMI, age and gender in spondylolisthesis patients who underwent lumbosacral xray examination at H Adam Malik Hospital Meda. The variables gender and BMI are the most significant risk factors. Spondylolisthesis patients with female risk factors are at risk of experiencing spondylolisthesis 6.5 times greater and patients who have an obese BMI are at risk of experiencing spondylolisthesis 4 times greater than patients without this condition at RSUP H Adam Malik Medan.*

Keywords: age, body mass index, gender, lumbosacral xray, spondylolisthesis

INTRODUCTION

Spondylolisthesis is a displacement of one vertebra relative to the vertebra below it.2 Current estimates of the prevalence of spondylolisthesis are 6 to 7% in 19 year olds, and up to 18% of adult patients undergoing MRI of the lumbar spine. Grade I spondylolisthesis accounts for 75% of all cases. Spondylolisthesis most often occurs at the L5-S1 level with anterior translation of the L5 vertebral body to the S1 vertebral body. 3 Patients with symptoms of low back pain (LBP) have a 5.3% -11% risk of developing spondylolisthesis, while spondylolisthesis patients without symptoms can occur. as much as 2.2%.[3] The initial examination for spondylolisthesis is a radiograph of the lumbosacral vertebrae. [7] A standing radiograph from the lateral position is often used to identify spondylolisthesis.[8] In spondylolisthesis, anterior posterior (AP) and lateral radiographs of the lumbosacral spine tend to show a cortical defect in the pars interarticularis of L5.[9]

Various factors can influence the occurrence of spondylolisthesis such as BMI, age and gender. In the spondylolisthesis group, 71.4% of patients were overweight (BMI > 25 kg/m2) and obese

compared with 50.6% in the reference group (P = 0.004). 5 Romero-Vagas showed that greater BMI significantly tended to the group of patients who were positive for spondylolisthesis were compared to the group who were negative for spondylolisthesis. This is caused by excessive axial load on the intervertebral discs and facet joints, which causes anterior displacement of the body and increases the risk of spondylolisthesis.[10]

Likewise with age, after the age of 40 years, women and men usually begin to experience spondylolisthesis, due to a degenerative process. The prevalence of spondylolisthesis in old age was found to be 25% in women and 19.1% in men with a female:male ratio of 1.3:1.[11] Apart from that, based on gender, in theory women tend to experience spondylolisthesis earlier. Data suggest that a decrease in estrogen during menopause is one factor that contributes to the development of degenerative spondylolisthesis in postmenopausal women.[3]

Research on the relationship between body mass index, age and gender with the degree of spondylolisthesis on lumbosacral x-ray photos has never been carried out in North Sumatra, so researchers are interested in carrying out this research and it is hoped that the results of this research can provide information regarding the causes of spondylolisthesis which can be linked to body mass index. age and gender can determine the appropriate actions and treatment for the patient.

METHOD

This research is an observational analytical study with a research design in the form of a cross-sectional study to see the relationship between body mass index, age and gender with the degree of lumbosacral spondylolisthesis on x-ray photos at Haji Adam Malik General Hospital, Medan. This research was carried out from September 2023 to April 2024. The research sample wasspondylolisthesis patients at H. Adam Malik General Hospital Medan who met the inclusion and exclusion criteria with a total sample size of 80 people. This research has passed ethical review by the Health Research Ethics Committee of the University of North Sumatra. The research subjects were patients> 20 years old with AP/Lateral erect lumbosacral xray results in the data storage of the Radiology Installation of Haji Adam Malik Hospital with spondylolisthesis expertise that can be evaluated as good. Patients with a history of trauma, history of congenital vertebral abnormalities, history of malignancy with vertebral metastases, history of vertebral infections and unstable lumbar disease will be excluded from this study.

Age, gender and body mass index measurements were obtained from medical record data. The results of measuring body mass index are classified into underweight, normal, overweight and obese according to Asian standards. From the results of the AP/Lateral erect lumbosacral xray photo, the location of lumbar spondylolisthesis was obtained with the classification Th12-L1, L1-2, L2-3, L3-4, L4-5 and L5-S1 and the degree of lumbar spondylolisthesis was classified according to Meyerding's classification which was divided into 5 degrees. In addition, there is an assessment of the presence or absence of lumbar scoliosis which is characterized by curvature of the vertebrae to the right/left lateral direction with a Cobb angle of >10° and lumbar spondylosis which is characterized by the presence of sclerosis, narrowing of the intervertebral disc and osteophytes in the patient. The xray photo results are the result of radiological examination expertise.

The data that has been collected is checked for completeness, then the data is coded, tabulated, and entered into the SPSS 23.00 computer program. The data is then analyzed statistically including univariate analysis to display the mean value and standard deviation if it is normally distributed and in median form with a range if it is not normally distributed. Bivariate analysis uses the Chi-Square test. If it does not meet the Chi-Square test requirements, Fisher's test is carried out, which is significant if the p value is <0.05. Multivariate analysis uses a logistic regression test where the variables analyzed bivariately with a p value <0.25 are continued to carry out a logistic regression test where the results with a p value <0.05 from the multivariate analysis are the most influential variables.

RESULTS

The samples in this study were lumbosacral xray results from 120 patients at HAM Hospital. Data collection was carried out from September 2023 to April 2024 and was carried out using a consecutive sampling technique. Data collection begins with sorting patients based on inclusion and

exclusion criteria based on medical record data and lumbar xray results obtained. Data on patients who met the inclusion and exclusion criteria were included as research subjects, then age, gender and BMI were recorded, then continued with an assessment of the degree of spondylolisthesis under the supervision of a Radiology specialist.

Characteristics of Spondylolisthesis Patients Who Undergo Lumbosacral Xray Examination at H Adam Malik General Hospital, Medan

The characteristics of the research subjects are shown in table 4.1. below this. It can be seen that based on BMI, the majority of obese patients, namely 64 patients (53.3%) experienced spondylolisthesis, the majority of spondylolisthesis patients were > 60 years old, 79 patients (65.8%) and based on gender, the number of patients suffering from spondylolisthesis was predominantly female. namely 75 patients (62.5%). In this study, assessing the degree of spondylolisthesis through lumbar xray examination in AP and lateral positions, then determining the degree of lumbar spondylolisthesis by classifying it based on the Meyerding classification. It was found that 98 patients (81.6%) had grade I spondylolisthesis and 22 patients (18.3%) had grade II spondylolisthesis.
Based on BMI, 47 patients (39.1%) with obesity experienced grade I spondylolisthesis and 17 patients (14.1%) with obesity experienced grade II spondylolisthesis. Based on age >60 years, 59 patients (41.9%) experienced grade I spondylolisthesis, 20 patients (16.6%) experienced grade II spondylolisthesis. Based on gender, 55 patients (48.5%) women experienced grade I spondylolisthesis and 20 patients (16.6%) women experienced grade II spondylolisthesis. None of the samples experienced grade III, IV and V spondylolisitis.

Table 1. Characteristics of spondylolisthesis patients who underwent lumbosacral xray examination at H Adam Malik General Hospital, Medan

Patient Characteristics		Degrees of Spondylolisthesis					
		I	II	III	IV	V	Total
Age	20 – 40 years	5 (4.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (4.1%)
	40 – 60 years	34 (28.3%)	2 (1.6%)	0 (0%)	0 (0%)	0 (0%)	36 (30%)
	≥60 years old	59 (49.1%)	20 (16.6%)	0 (0%)	0 (0%)	0 (0%)	79 (65.8%)
Gender	Man	43 (35.8%)	2 (1.6%)	0 (0%)	0 (0%)	0 (0%)	45 (37.5%)
	Woman	55 (48.5%)	20 (16.6%)	0 (0%)	0 (0%)	0 (0%)	75 (62.5%)
Body Mass Index (BMI)	Normal	5 (4.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (4.1%)
	Overweight	46 (38.3%)	5 (4.1%)	0 (0%)	0 (0%)	0 (0%)	51 (42.5%)
	Obesity	47 (39.1%)	17 (14.1%)	0 (0%)	0 (0%)	0 (0%)	64 (53.3%)
Total spondylolisthesis patients		98 (81.6%)	22 (18.3%)	0 (0%)	0 (0%)	0 (0%)	120 (100%)

Distribution of Anatomical Locations of Spondylolisthesis, Scoliosis, and Spondylosis based on Lumbosacral Xray Examination at H Adam Malik Hospital

Table 2 shows the distribution of spondylolisthesis locations found mostly in L4-5, a total of 64 patients (53.3%), namely 52 patients (43.3%) with grade I spondylolisthesis and 12 patients (10%) with grade II spondylolisthesis. . Only 4 patients (3%) had spondylolisthesis with an anatomical location at L2-3 and there were around 7 (5%) patients with spondylolisthesis locations in more than 2 locations.

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Scoliosis was found in 66 patients (55%) with 56 patients (46.6%) grade I spondylolisthesis and 10 patients (8.3%) grade II spondylolisthesis. Most of the spondylolisthesis patients also experienced spondylosis, namely 116 (96%) in 94 patients (78.3%) with grade I spondylolisthesis and 22 patients (18.3%).

Table 2. Distribution of anatomical locations of spondylolisthesis, scoliosis and spondylosis based on lumbosacral xray examination at H Adam Malik Hospital

Patient Characteristics		Degrees of Spondylolisthesis					Total
		I	II	III	IV	V	
Location of Spondylolisthesis	Th12-L1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	L1-2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	L2-3	2 (1.6%)	2 (1.6%)	0 (0%)	0 (0%)	0 (0%)	4 (3.3%)
	L3-4	8 (6.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	8 (6.6%)
	L4-5	52 (43.3%)	12 (10%)	0 (0%)	0 (0%)	0 (0%)	64 (53.3%)
	L5-S1	30 (5%)	7 (5.8%)	0 (0%)	0 (0%)	0 (0%)	37 (30.8)
	> 2 Locations	6 (5%)	1 (0.8%)	0 (0%)	0 (0%)	0 (0%)	7 (5.8%)
Scoliosis	Yes	56 (46.6%)	10 (8.3%)	0 (0%)	0 (0%)	0 (0%)	66 (55%)
	No	42 (35%)	12 (10%)	0 (0%)	0 (0%)	0 (0%)	54 (53.3%)
Spondylosis	Yes	94 (78.3%)	22 (18.3%)	0 (0%)	0 (0%)	0 (0%)	116 (96.6%)
	No	4 (3.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (3.3%)

Analysis of the Relationship between Spondylolisthesis and BMI, Age and Gender of Patients Who Undergo Lumbosacral Xray Examination at H Adam Malik General Hospital Medan

In table 3, it can be seen that after statistical analysis using the Chi square and Fisher tests, a significant relationship was obtained between spondylolisthesis and age, gender and BMI with a p value <0.05.

Table 3. Analysis of the relationship between spondylolisthesis and BMI, age and gender of patients undergoing lumbosacral xray examination at HAM Hospital Medan

Patient Characteristics		Degrees of Spondylolisthesis		p value
		0-25%	26-50%	
Age	20-40 years	5(4.1%)	0 (0%)	**0.008***
	40-60 years old	34 (28.3%)	2 (1.6%)	
	≥60 years old	59 (49.1%)	20 (16.6%)	
Gender	Man	43 (35.8%)	2 (1.6%)	**0.001****
	Woman	55 (48.5%)	20 (16.6%)	
Body Mass Index (BMI)	Normal	5 (4.1%)	0 (0%)	**0.004***
	Overweight	46 (38.3%)	5 (4.1%)	
	Obesity	47 (39.1%)	17 (14.1%)	

Analysis of risk factors for BMI, age and gender as risk factor of spondylolisthesis at Haji Adam Malik General Hospital, Medan.

Table 4 shows the multivariate analysis used to identify factors that are risk factors of spondylolisthesis. The risk factors for spondylolisthesis assessed in this study were BMI, age and gender. Variables resulting from bivariate analysis that had a p value <0.25 were included in the logistic regression analysis of the incidence of spondylolisthesis. In the analysis it was found that the variables BMI and gender were risk factors that were statistically significant with a p value <0.05. Gender as a risk factor for spondylolisthesis with a value of p=0.018. BMI as a risk factor for spondylolisthesis with p value = 0.019. A spondylolisthesis patient with female risk factors is at risk of experiencing spondylolisthesis 6.490 times greater and a patient who has a high BMI is at risk of experiencing spondylolisthesis 4.024 times greater than patients without this condition.

Table 4.Multivariate Analysis of Spondylolisthesis Risk Factors

Variable	Coefficient	p value	OR	IK95%	
				Min	Max
Age	3,302	0.069	4,065	0.896	18,449
Gender	5,586	0.018	6,490	1,376	30,606
BMI	5,538	0.019	4,024	1,262	12,828

Before carrying out the inferential test analysis, a reliability test (Kappa test) was carried out to ensure the similarity of the reading results. The spondylolisthesis assessment was carried out directly by the researcher and supervisor I. From the variables measured, the Kappa test result was 98%. Based on the results of this test, the inferential analysis is continued using one of the measurement data sets.

DISCUSSION

BMI risk factors influence the incidence of spondylolisthesis in spondylolisthesis patients at Haji Adam Malik General Hospital, Medan

According to Schuller in 2011, in the spondylolisthesis group, 71.4% were overweight (BMI > 25 kg/m2) and obese compared to 50.6% in the reference group (p=0.004).[5] Romero-Vagas in 2013 showed that BMI was higher. significantly tended to be greater in the group of patients who were positive for spondylolisthesis than in the group who were negative for spondylolisthesis. This is caused by excessive axial load on the intervertebral discs and facet joints, which causes anterior displacement of the body and increases the risk of spondylolisthesis.[10]

Another study conducted by Radovanovic et al in 2017 on the relationship between BMI and spondylolisthesis concluded that the average BMI was significantly higher in the group of patients who were positive for spondylolisthesis than in the negative group for spondylolisthesis. High BMI can cause increased axial load on the L4-L5 intervertebral discs and facet joints, and cause anterior displacement of the body and increase the risk of degenerative spondylolisthesis. [5]

Meanwhile, research by He et al in 2014 showed that the increase in BMI in men and women occurred due to increased biomechanical pressure which resulted in compression and axial load on the lumbar facet joints. In the older population, men and women with spondylolisthesis appear to have a short body, which can be caused by narrowing of the intervertebral disc.[12]

Age Risk Factors Affect the Occurrence of Spondylolisthesis in Spondylolisthesis Patients at Haji Adam Malik General Hospital, Medan

This research is in accordance with research conducted by Kalichman in 2009 which showed that degenerative spondylolisthesis is very rare before the age of 50 years. The prevalence of disc narrowing, facet joint OA and spondylolisthesis was significantly associated with increasing age (p<0.0001). The prevalence of degenerative spondylolisthesis is not found in those aged <40 years and the prevalence increases in the age group >60 years. This may be caused by prolonged exposure to harmful factors and the accumulation of degenerative changes. The decrease in bone density quality

which is common in the elderly has a significant impact on the occurrence of spondylolisthesis. Low bone mineral density (BMD) values are more often found in elderly patients.[12] In research conducted by Jacobsen et al on the relationship between degenerative spondylolisthesis and epidemiological data such as age, gender and BMI involving 254 cases of spondylolisthesis, it was concluded that BMI and lumbar lordosis were significantly associated with degenerative spondylolisthesis in women. Meanwhile, in men, no individual risk factors were found, except for age. [9]

Spondylolisthesis is mostly caused by increasing age, known as degenerative spondylolisthesis, which is a disorder that causes a shift in one of the vertebral bodies due to degenerative changes. In contrast to spondylolisthesis, spondylolysis is accompanied by a pars interarticularis defect (spondylolysis), and in DS the entire upper vertebra (the vertebral body and the posterior part of the vertebra including the neural arch and processes) shifts towards the vertebral body below. The main mechanism of degenerative spondylolisthesis is spinal displacement with (1) arthritis of the facet joints with loss of normal structural support (2) non-functioning of the ligament stabilization components due to hyperlaxity and (3) ineffective muscle stabilization.[11]

Risk Factors Gender influences the incidence of Spondylolisthesis in Spondylolisthesis patients at Haji Adam Malik General Hospital, Medan

In this study, the majority of patients were female, this is in accordance with previous research. In another study conducted by Bakilan et al in 2021, it was also found that 245 spondylolisthesis patients (70.4%) were women, and the remaining 103 spondylolisthesis patients (29.6%) were men.[13]
He et al in 2014 stated that the incidence of spondylolisthesis in Chinese citizens was higher in women than in men ($p<0.001$), in women there was also a higher incidence of grade II spondylolisthesis ($p=0.07$). Various other studies also show the same thing that the incidence of spondylolisthesis is more likely to occur in women than men.[12]

Postmenopausal estrogen deficiency and differences in the distribution of comorbid factors such as diabetes, obesity, and metabolic syndrome between genders may account for these differences. Degenerative changes in the disc may then lead to a higher prevalence of degenerative spondylolisthesis.[14]
Joint weakness, pregnancy and oovorectomy are considered predisposing factors for spondylolisthesis in women. Additionally, intervertebral disc narrowing is more severe in women which may lead to a higher ratio of degenerative spondylolisthesis in women. Loss of elasticity in the paraspinal ligament system due to hormonal changes after oophorectomy can cause degeneration and development of spinal displacement at L5-S1.[11] Female gender and larger facet joint angles have consistently been associated with an increased risk of degenerative spondylolisthesis in several studies. Increased sagittalization of the facet joints limits the ability to resist anterior displacement, and is associated with hypermobility and the development of degenerative spondylolisthesis.[13]

Distribution of Anatomical Locations and Frequency of Degrees of Spondylolisthesis, Scoliosis, and Spondylosis in Spondylolisthesis Patients Based on Lumbosacral Xray Examination at Haji Adam Malik Hospital

Lumbar spondylolisthesis most often occurs in the lower lumbar spine.This spondylolisthesis generally occurs at the L4-5 level, because the strong iliolumbar ligaments resist movement of the fifth lumbar vertebra, and at the L5-S1 level. This condition is triggered by the intervertebral discs weakening so that they become incompetent. Anteroposterior translational shear forces resulting from long-standing soft tissue instability accelerate the degenerative changes observed in the facet joints to the point of subluxation of the vertebra relative to the other vertebrae. [9] Meyerding's classification is often used to assess the severity of the “drift” or forward translation of a vertebra relative to a vertebral segment caudal. The shift value is very relevant because it provides prognostic information and can influence patient management.[16] These spondylolisthesis patients may also be accompanied by scoliosis with an increased level of displacement, according to complaints of pain that can cause atypical scoliosis caused by muscle spasms. Simultaneous rotational shift of spondylolisthesis segments can also create curvature of the vertebral curvature. [17] The pathogenesis of degenerative spondylolisthesis is

closely related to spondylosis which is multifactorial and begins with degeneration of the intervertebral disc and facet joints. Progressive degeneration can cause spinal instability.[13]

Distribution of Locations and Degrees of Spondylolisthesis based on Lumbosacral Xray Examination at Haji Adam Malik Hospital

In this study, spondylolisthesis was most common at L4-5 with 52 patients (43.3%) experiencing grade I spondylolisthesis and 11 patients (9.1%) with grade II spondylolisthesis. This is in accordance with research conducted by Devine et al in 2012 which also showed that displacement most often occurred at the L4-5 level and rarely exceeded 30% of the width of the adjacent vertebral body. 15 The study by Mazurek et al in 2023 also found that in 66% of cases, degenerative spondylolisthesis was only involves one spinal level, most commonly L4-5.[14] In this study, multiple levels of lumbar spondylolisthesis were also found in 7 people (5.8%). According to Liu in 2015, there were more multiple levels of lumbar spondylolisthesis in men than women, which is usually related to exercise, trauma or a history of lifting heavy weights. Multiple level lumbar spondylolisthesis is often at L3-5.[18]

Multiple level spondylolisthesis is a more serious event than spondlolisthesis which only involves one level. According to Zhang et al. In 2018, women experienced more progression of spondylolisthesis. It was found that a higher degree of displacement of the vertebral bodies at the L3-4 and L4-5 levels often occurs due to isthmic fractures. The higher the vertebral instability, the higher the incidence of isthmic fractures. [19] In this study, the majority of patients were categorized as Meyerding grade I, 81.6%. This is in accordance with a study conducted by Bakilan et al in 2021, where grade I anterolisthesis was found in 90.6% of all spondylolisthesis cases, and was at L5-S1.20 Possible causes could be caused by high pedicle–facet angle values, coronal orientation from the L5-S1 side, and the position of the sagittal side joints. Meanwhile, an additional factor influencing the formation of a shift at the L4-5 level may be a weakening of the iliopsoas ligament. Research regarding the condition of the ligamentous apparatus as the etiology of degenerative spondylolisthesis can be found in several studies.

The paraspinal muscles and other muscle groups, such as the deep abdominal muscles, are involved in maintaining spinal stability. Weakening of the paraspinal muscles, transverse abdominis, or pelvic floor is another factor that influences the occurrence of degenerative spondylolisthesis.[14] According to Aoki in 2020, of the 19 patients who experienced spondylolisthesis, they experienced Meyerding grade I spondylolisthesis, 7 spondylolisthesis patients suffered from Meyerding grade 2 spondylolisthesis, however, no patient showed spondylolisthesis greater than Meyerding grade II. In patients who did not show spondylolysis, the prevalence of spondylolisthesis was significantly lower (7.4% of patients, $p<0.001$) when compared with patients with spondylolysis. No patient demonstrated spinal displacement greater than Meyerding grade I. [21]

Distribution of Scoliosis Incidents in Spondylolisthesis Patients Based on Lumbosacral Xray examination at Haji Adam Malik Hospital

This study also found cases of scoliosis in a total of 66 patients (55%) in 56 patients (46.6%) with grade I spondylolisthesis and 10 patients (8.3%) with grade II spondylolisthesis. Bakilan et al found that the scoliosis rate in spondylolisthesis patients was 37.5%. This association between scoliosis and spondylolisthesis may be related to curve progression due to muscle contracture and increased pars interarticularis defects in scoliosis compared with the normal population. 20 In a study investigating the association between scoliosis and spondylolisthesis, scoliosis was found in 42% of patients with symptomatic spondylolisthesis. Spondylolisthesis associated with spinal curvature can affect the sagittal curvature or sagittal balance of the spine.[22]

The pathoanatomy of the relationship between lateral spondylolisthesis and scoliosis is divided into three: namely the first is a patient with a history of spondylolisthesis in a family member who suffers from scoliosis, indicating that the pathoanatomy of the two is not related, where scoliosis and spondylolisthesis occur idiopathically. The second is a spondylolisthesis sufferer who complains of sciatic pain but the sufferer presents with scoliosis deformity due to muscle spasm and the third is a sufferer who has olisthetic bones. Lateral spondylolisthesis is associated with scoliosis characterized by sciatic pain.[23]

Two main types of scoliosis caused by spondylolisthesis have been defined in the literature, namely spastic scoliosis (SS) and olisthetic scoliosis (OS). SS is caused by muscle spasms and is similar to scoliosis in that it is associated with other painful spinal pathologies, such as disc herniation, with a typical lateral tilt of the spine. Pure spastic scoliosis, which is the most common type, has a Cobb angle of no more than 20° and almost no spinal rotation.[24] Olysthetic scoliosis, which is caused by rotation and tilt of L5 which results in displacement of the body with or without spasm factors. As the foundation of the spine, rotation and tilt of L5 can cause a compensation curve above L5, and the peak of the compensation curve is usually located in the lumbar region with mild vertebral rotation of no more than Nash-Moe Method Degrees.[24]

Scoliosis caused by spondylolisthesis with a Cobb angle greater than 20°, which includes more muscle spasm factors, is similar to pure spastic scoliosis. This differentiation of subtypes is necessary because, when we observe scoliosis with a Cobb angle > 20° associated with spondylolisthesis, it is not easy to determine whether the curve is independent or caused by spondylolisthesis. This type of scoliosis may be confused with idiopathic scoliosis. The important thing to differentiate is that idiopathic scoliosis has significant spinal rotation at the apex corresponding to the Cobb angle, whereas scoliosis caused by spondylolisthesis has no or little spinal rotation at the apex and usually has significant coronal imbalance. [24]

Distribution of Spondylosis Incidents in Spondylolisthesis Patients Based on Lumbosacral Xray Examination at Haji Adam Malik Hospital

The majority of spondylolisthesis patients in this study experienced spondylosis, namely a total of 116 patients (96%) with 94 patients (78.3%) experiencing grade 1 spondylolisthesis and 22 patients (18.3%) with grade II spondylolisthesis. According to Bakilan in 2021, the most common finding on radiographs in spondylolisthesis patients was spondylosis (75.8%) in men (77.6%) and women (75.1%). In addition, sclerosis (95%), osteophytes (62.5%) and narrowing of the intervertebral disc (62.5%) were found in spondylolisthesis patients. This supports the idea that the pathogenesis of spondylolisthesis is related to spondylosis.[20]

Wang et al in 2017 reported that osteophytes can cause segment instability and narrowing of the intervertebral disc space which causes degenerative lumbar spondylolisthesis. There are also studies on other spinal pathologies that increase the risk of spondylolisthesis. It was reported that the risk of spondylolisthesis increased fourfold with the presence of sacralization at L5. In another study in athletes, stress fracture was the most dominant cause of spondylolisthesis, which was associated with isthmic spondylolisthesis.[11]

Relationship between BMI, Age and Gender with Spondylolisthesis at Haji Adam Malik General Hospital, Medan

Goode et al in 2022 showed that obesity is a risk factors of spondylolisthesis and women experience spondylolisthesis more often. Muraki et al found that BMI was a significant risk factor for lumbar spine degeneration. [25] The association between menopause and degenerative spondylolisthesis was higher in postmenopausal women than in men of the same age. Before the age of 50 years, degenerative spondylolisthesis is rare and the prevalence of congenital spondylolisthesis is actually more common in men. Decreased hormonal levels in postmenopausal women can be associated with disc degeneration and narrowing of the disc space, increased incidence of osteoarthritis, including facet joints and weakening of the elasticity of the paraspinal ligaments. It has been shown that hormone replacement treatment (HRT) increases muscle strength in postmenopausal women. Taaffe et al showed that HRT maintained or improved skeletal muscle quality in early postmenopausal women, and had a positive effect on muscle performance.[11]

Relationship between IMT and Spondylolisthesis at Haji Adam Malik General Hospital, Medan

Based on this research, the relationship between spondylolisthesis and BMI also has a statistically significant value with a value of p = 0.004 in this study. In line with Wang et al's multivariate analysis study, spondylolisthesis (OR=1.819, p=0.027) and BMI (OR=1.658, p=0.001)

were significantly associated. 22 The prevalence of facet joint osteoarthritis (OA) was statistically higher in the obese group OR (95% CI):2.8 (1.1–7.2). In Kalichman et al's research, it was shown that the L4-L5 spinal level was the level that most often experienced OA. The results showed a significant relationship between BMI and facet joint OA only at the L4-L5 spinal level OR (95%CI): 1.08 (1.01-1.16).[26] A study conducted by He et al in 2014 on an elderly population in China showed that greater BMI was a risk factor for spondylolisthesis in both women and men. As many as 71.4% of patients with displacement were overweight or obese. [12] Schuller et al in 2011 also noted a relationship between high BMI values and sagittal facet joint orientation at the L4-5 level. An increase in body mass index (BMI), an axial load on the intervertebral discs and facet joints, causes an increase in compressive forces on the spine. Chronic exposure to these stressors can lead to increased intersegmental mobility, anterior displacement of the trunk, and increased risk of degenerative spondylolisthesis.[14] The BMI sample in Tedyanto's 2018 study consisted of 55% overweight patients and 17% obesity. This study shows an odds ratio (OR) of 6,089, which shows that patients who are overweight have a 6,089 times greater positive risk of spondylolisthesis than patients who have a normal BMI. Research conducted on risk factors for spondylolisthesis states that BMI has a significant influence on spondylolisthesis with a significance p value <0.001.[3]

Relationship between Age and Spondylolisthesis at Haji Adam Malik General Hospital, Medan

Based on this research, spondylolisthesis is associated with age, the results of statistical analysis obtained a p value = 0.008. So it can be concluded that there is a statistically significant relationship between the incidence of spondylolisthesis and increasing age. According to Davine in 2012 two studies used multivariate models to evaluate the relationship between age and DS. First, a 1-year increase in age was associated with a 9% increase in DS risk (odds ratio [OR] = 1.09; 95% confidence interval [CI]: 1.01–1.17; p= 0.019). Others reported a significant association between age and DS only at the L4 and L5 levels (p < 0.001 and p = 0.02, respectively) in women, and only at L4 (p < 0.001) in men. [15]

Age has the potential to be a determining factor for degenerative conditions. 26 The prevalence of disc narrowing, osteoarthritis (OA) of facet joints, and degenerative spondylolisthesis showed a significant linear trend (p<0.0001) with increasing age. The development of spinal degeneration with increasing age is associated with a "linear" increase in the prevalence of "spondylitis deformans" from 0% to 72% between the ages of 39 and 70 years. 26 According to Da He et al. In 2021, the prevalence of spondylolisthesis at the age of 60-64 years was higher than in at the age of 55-59 years.27 The prevalence of degenerative spondylolisthesis is strongly related to gender and age. Where the incidence of degenerative spondylolisthesis is very rare under the age of 50 years, and at the age of over 50 years the incidence increases in women and men, especially in women. Elderly Caucasian residents have a higher prevalence of degenerative spondylolisthesis, around 60-70% compared to Chinese elderly people, with a female to male ratio of around 1.3:1.[11]

According to Aoki in 2020, the prevalence of spondylolisthesis showed an increase depending on age in spondylolysis patients, as well as non-spondylolysis patients. The majority of spondylolysis patients (90%) aged ≥60 years showed spondylolisthesis, while only 8.3% of patients aged <60 years showed spondylolisthesis (p=0.02). In non-spondylolysis patients, the prevalence of spondylolisthesis in patients ≥60 years (10.7%) was significantly lower than in spondylolysis patients ≥60 years (78.3%, p<0.001). [21]

Relationship between gender and spondylolisthesis at Haji Adam Malik General Hospital, Medan

Based on this research, spondylolisthesis is associated with gender, in women the incidence of spondylolisthesis is higher than in men, with the results of statistical analysis obtaining a p value = 0.001. According to Wang et al. in 2017, there was a 3 times chance of spondylolisthesis occurring in non-oovorectomy patients p<0.005 compared to non-oovorectomy patients due to decreased estradiol levels which is a risk factor for degenerative spondylolisthesis in L4-511. For example, research conducted by Horikawa et al. reported that the female to male ratio was 2.34:1 in Japan. [20] The prevalence of degenerative spondylolisthesis in Wang et al.'s 2017 study was also greater in women with a male/female prevalence ratio of 1.3: 1.11 In another study conducted on an elderly population in

China, it was also found that more women experienced spondylolisthesis, namely 25% and 19.1% of men. So it can be concluded that there is a statistically significant relationship between the incidence of spondylolisthesis and women's risk factors.[20] The association between the prevalence of spondylolisthesis and patient gender may be related to the influence of the female sex hormone estrogen on tissues associated with the human musculoskeletal system. The effectiveness of HRT was found in other degenerative conditions such as thinning atherosclerosis, facet joint osteoarthritis, and intervertebral disc degeneration. However, women taking estrogen are more susceptible to anterolisthesis at the L5-S1 level. In cases of retrolisthesis, the increase in the incidence of shifting is two-fold compared with women who do not receive supplementation.[14]

Mazurek 2023 showed that a large number of estrogen receptors in joints significantly correlated with the severity of degenerative changes. It manifests as erosion, changes in the subchondral bone, and fibrillation and architectural disruption of the cartilage surface. Increased estrogen receptors have also been demonstrated in patients with degenerative spondylolisthesis also suggesting an association between this type of receptor polymorphism and the severity of shift-related symptoms.[14]

Risk Factor Analysis of BMI, Age and Gender as Risk Factors of Spondylolisthesis at Haji Adam Malik General Hospital Medan

In this study, the risk factors for spondylolisthesis assessed were BMI, age and gender. Variables resulting from bivariate analysis that had a p value <0.25 were included in the logistic regression analysis of the incidence of spondylolisthesis. In the analysis it was found that the variables BMI and gender were risk factors that were statistically significant with a p value <0.05. Gender as a risk factor for spondylolisthesis with a value of p=0.018. BMI as a risk factor for spondylolisthesis with p value = 0.019. A spondylolisthesis patient with female risk factors is at risk of experiencing spondylolisthesis 6.490 times greater and a patient who has a high BMI is at risk of experiencing spondylolisthesis 4.024 times greater than patients without this condition.

This is supported by He et al in 2014 who stated that the incidence of spondylolisthesis in Chinese citizens was higher in women than in men (p<0.001), in women there was also a higher incidence of grade II spondylolisthesis (p=0.07).[12] Bakilan at al year 2021 also shows a higher incidence of spondylolisthesis in women with a higher anterolisthesis shift compared to the most retrolisthesis at the L5-S1 level of 1.[20] According to Aoki et al. in 2020, the prevalence of spondylolisthesis degrees is significantly higher in spondylolysis patients than in non-spondylolysis patients (p<0.001). Women showed a significantly higher prevalence of spondylolisthesis (11.6%) than men (4.2%) in patients without spondylolysis. No patients with isthmic spondylolisthesis underwent fusion surgery, indicating that the majority of these patients do not have severe disability requiring surgical treatment.[21]

Research conducted by Tedyanto in 2018 at Dr. Hospital. Rumkital Ramelan Surabaya in examining 39 spondylolisthesis patients from 72 research samples using the chi-square method found a significant correlation between increasing BMI and the incidence of spondylolisthesis (p<0.05) where patients with an overweight BMI would have a 6.089 times higher risk of experiencing spondylolisthesis compared to patients with an overweight BMI. the BMI is normal.[3]

This study has several limitations, namely, degenerative spondylolisthesis and isthmic spondylolisthesis were not investigated because there was no xray examination in the oblique position. Furthermore, due to the retrospective design, this study could not evaluate the level of pain, function, pelvic angle, and degree of lordosis. Increased lumbar lordosis may place additional stress on spinal ligaments and play a role in the pathogenesis of spondylolisthesis so further research is needed evaluating the relationship between the degree of lordosis and spondylolisthesis. The strength of this study is that it not only evaluates the distribution of age, gender, and BMI but also evaluates other radiological findings such as spondylosis and scoliosis that accompany spondylolisthesis.

CONCLUSION

Based on BMI, the majority of spondylolisthesis patients were in the obesity category, based on age, the majority were >60 years old and based on gender, the majority were female. Based on

anatomical location, the most spondylolisthesis patients were at level L4-5 and the most were grade 1 spondylolisthesis. There was a significant relationship between spondylolisthesis and BMI, age and gender in spondylolisthesis patients who underwent lumbosacral xray examination at H Adam Malik General Hospital Medan with a p value <0 .05. The variables gender and BMI are the most significant risk factors. Spondylolisthesis patients with female risk factors are at risk of experiencing spondylolisthesis 6,490 times greater and patients who have an obese BMI are at risk of experiencing spondylolisthesis 4,024 times greater than patients without this condition at RSUP H Adam Malik Medan.

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