Modification of the Safe Corridor for Oblique Lumbar Interbody Fusion Based on Postural Changes and Body Composition. An Observational, Multicenter Study Using MRI

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ABSTRACT

Introduction: Minimally invasive spine surgery (MISS) has gained popularity in recent years. New and less invasive techniques have emerged as the preferred procedures for certain pathologies. The size of the aorta-psoas corridor is decisive when choosing the oblique interbody fusion technique. **Objectives:** To describe the changes in the size of the aorta-psoas corridor in the right lateral decubitus and supine decubitus positions by magnetic resonance imaging and their association with body mass index. **Materials and Methods:** 13 volunteers underwent MRI of the disc spaces from L1-L2 to L4-L5 in the supine and right lateral decubitus positions. The corridor was measured, and the sizes at each level were compared. **Results:** A statistically significant increase in the size of the aorta-psoas corridor and the artery-disc distance was obtained when positioning the patient in the right lateral decubitus position. However, these have no significant relationship with BMI. **Conclusions:** The use of MRI in pre-surgical planning is extremely important. This study reveals the mobility of the abdominal structures. We can conclude that, as stated in the objective of the study, significant changes occur in the aorta-psoas corridor and the artery-disc distance when the patient is positioned in the right lateral decubitus position.

Keywords: OLIF; MISS; minimally invasive spine surgery.

Level of Evidence: IV

Modificación del corredor aorto-psoas para el acceso oblicuo lumbar intervertebral según los cambios posturales y la composición corporal. Estudio multicéntrico observacional mediante resonancia magnética

RESUMEN

Introducción: La cirugía mínimamente invasiva de columna se ha vuelto cada vez más popular en los últimos años. Se han desarrollado técnicas nuevas y menos invasivas que se han convertido en procedimientos de elección para determinadas enfermedades. El tamaño del corredor aorto-psoas es un factor determinante al elegir la técnica oblicua de fusión intersomática. **Objetivos:** Describir las modificaciones en el tamaño del corredor aorto-psoas en decúbito lateral derecho y decúbito supino mediante resonancia magnética y su asociación con el índice de masa corporal. **Materiales y Métodos:** Se realizó una resonancia magnética de los espacios discales de L1-L2 a L4-L5 a 13 voluntarios en decúbito supino y decúbito lateral derecho. Se midió el corredor y se comparó el tamaño en cada nivel. **Resultados:** El tamaño del corredor aorto-psoas y de la distancia arteria-disco tuvo un aumento estadísticamente significativo al posicionar al paciente en decúbito lateral derecho. **Conclusiones:** La resonancia magnética es de suma importancia en la planificación prequirúrgica, pues deja en evidencia la movilidad de las estructuras abdominales. Se producen cambios significativos en el corredor aorto-psoas y la distancia arteria-disco al ubicar al paciente en decúbito lateral derecho. Sin embargo, estos cambios no tienen una relación significativa con el índice de masa corporal.

Palabras clave: Fusión intersomática lumbar oblicua; cirugía mínimamente invasiva; cirugía de columna.

Nivel de Evidencia: IV

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INTRODUCTION

Since lumbar interbody fusion techniques were first described, the most widely adopted procedures by spine surgeons have been those performed via the traditional posterior approach: posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF).[1-7] In the last 15 years, multiple anterolateral approaches have been gaining ground and becoming established as the techniques of choice for specific cases. Unlike posterior interbody techniques, anterolateral approaches allow wide exposure of the disc space, which is not obstructed by the dural sac and neural elements.[4,7-10] Consequently, large interbody devices can be placed far in excess of the size and dimensions of posterior devices.[4,7,11,12] The rise of anterolateral approaches has been accompanied by minimally invasive spine surgery techniques that have become procedures of choice for many spine surgeons worldwide.[4,7-10] Several minimally invasive procedures have been described for the lumbar intervertebral space, including anterior lumbar interbody fusion (ALIF), oblique lumbar interbody fusion (OLIF), lateral lumbar interbody fusion (LLIF), TLIF, and PLIF.[1-5,7-10]

The OLIF technique is a minimally invasive procedure described by Mayer in 1977 that emerged as a possible solution to the disadvantages of the ALIF and LLIF techniques.[7-10,12-16] Examples of these include nerve and psoas muscle injury, which cause discomfort and weakness.[12-13,17,18] The ALIF technique in particular is associated with a higher risk of vascular injury, ureteral injury and even sacral plexus injury.[7,9,12,18] To avoid this type of injury, retroperitoneal lumbar interbody fusion (OLIF) methods using an approach between the aorta and the psoas have been applied.[7-10,18-21] Another factor that influenced the rise of OLIF as an alternative surgical technique is that, at L4-L5, the iliac crests create an anatomical impediment to the use of LLIF. In contrast, this technique allows for interbody device insertion at L5-S1 with minimal vascular complications by modifying the technique for safe iliac vessel mobilization by first ligating the iliolumbar vein.[20-24] The surgical technique consists of a lateral approach in the right lateral decubitus (RLD) position. Discectomy and interbody device placement are performed through an oblique corridor whose limits are located between the medial border of the psoas major muscle and the lateral border of the lumbar vessels (aorta/iliac), a space known as the safe corridor.[18,20-29]

Magnetic resonance imaging (MRI) is considered a mandatory preoperative study when planning the OLIF technique; it can define its feasibility by assessing the size of the corridors and the position of the vascular components.[30,31] However, this study is usually performed in the dorsal decubitus position, that is, in a different position from the one in which the surgical procedure is performed. We believe that abdominal structures are more mobile the more the patient's abdominal fat; therefore, patients with a narrow corridor in the supine decubitus (SD) position may be candidates for an oblique approach if evaluated with an MRI in RLD.

The aim of this study was to describe the modifications that occur specifically in the corridor size used for the OLIF technique when changing the patient's position from SD to RLD during an MRI, and to describe its association with body composition.

MATERIALS AND METHODS

A descriptive, observational study was carried out. The study was approved by the Ethics Committee of Hospital Alemán de Buenos Aires, Argentina (PRIISA.BA system registry number: 1997).

Thirteen volunteers, of both sexes, >18 years old who had undergone MRI between April and June 2020 were included. Exclusion criteria were: pregnancy, vertebral fractures, previous abdominal or thoracic surgery, or any contraindication for MRI.

Twenty-six MRIs were performed in 13 patients. A 1.5 Philips© Tesla Multiva scanner was used in two different centers. In the first instance, the study was performed with the patient positioned in SD and then in RLD (Figure 1). Sagittal and axial slices were taken in T1-weighted and T2-weighted sequences. Using a scale with a measuring rod (the same in all cases), body height and weight were determined and the body mass index (BMI) was obtained for each patient. Measurements were always taken in the morning before the MRI.

The OsiriX® system version 12.5.2. was used to measure the aorta-psoas safe corridor and the artery-disc distance in the L1-L2, L2-L3, L3-L4 and L4-L5 spaces, in both the SD and RLD positions (Figure 2). All measurements were performed by an orthopedic physician specializing in spine.

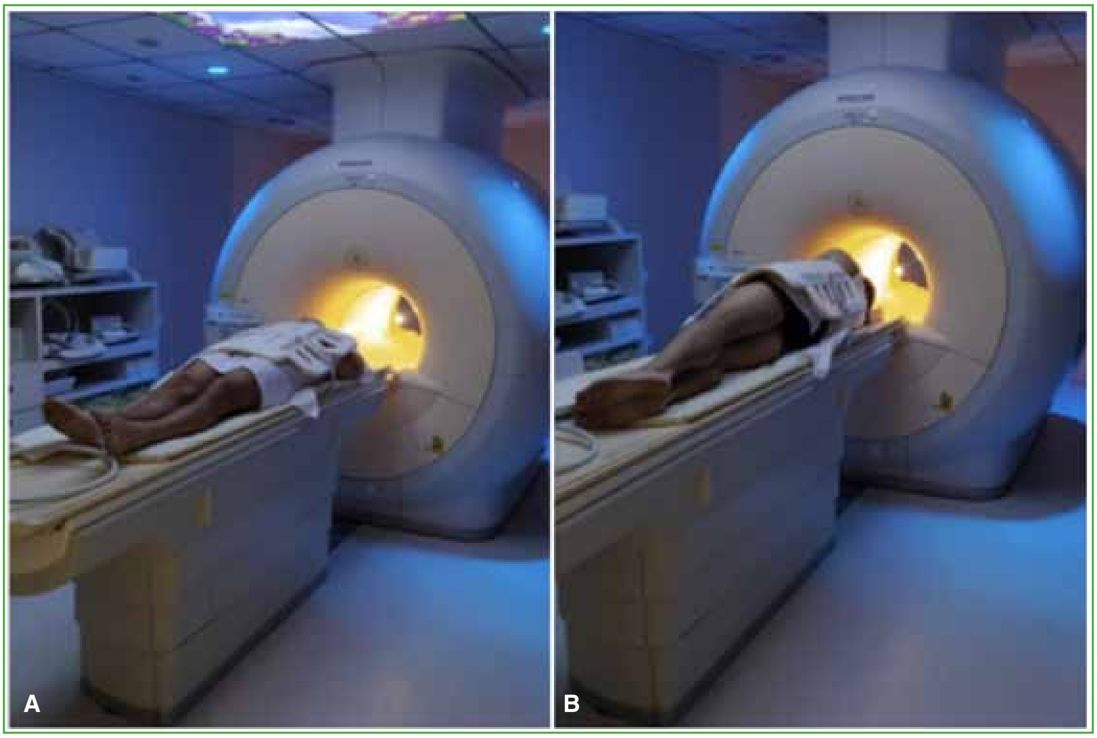

Figure 1. Magnetic resonance imaging. **A.** Patient in the supine decubitus position. **B.** Patient in the right lateral decubitus position.

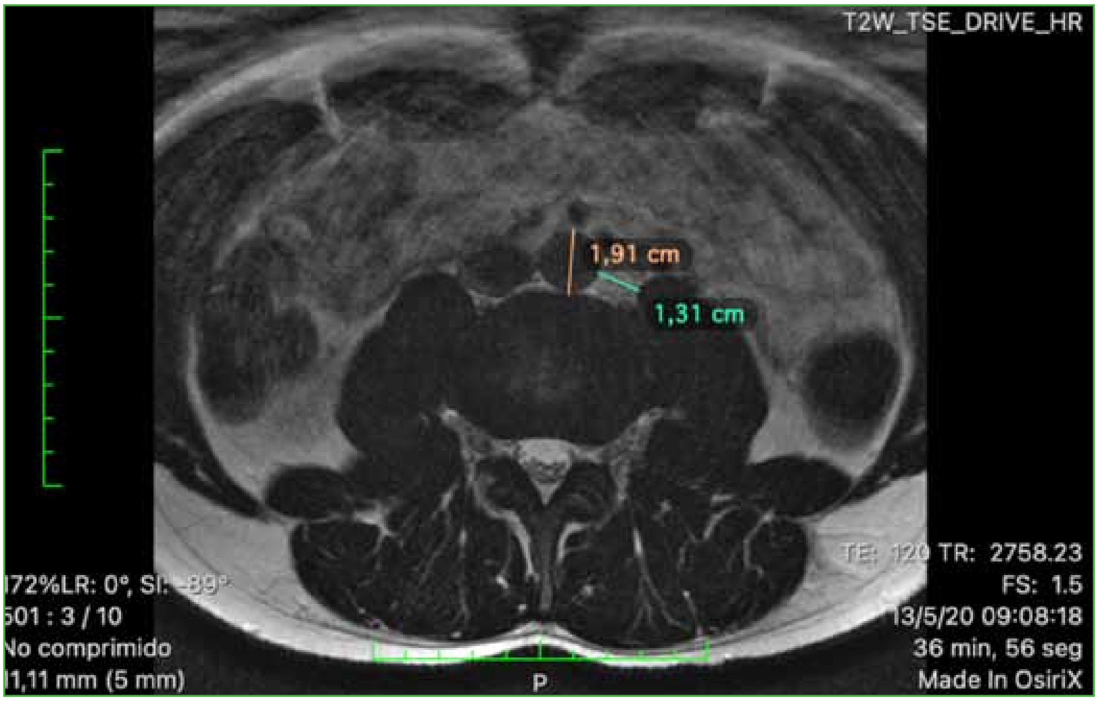

Figure 2. Magnetic resonance imaging of the intervertebral disc, axial section, where measurements are exemplified. For the artery-disc distance, it is from the most anterior point of the artery to the most anterior point of the intervertebral disc. For the aorta-psoas corridor, it is from the most lateral point of the artery to the most medial point of the psoas muscle.

Statistical Analysis

For comparisons between variables with normal distribution, Student's t test for related samples (parametric) was applied, while when an asymmetric distribution was found in at least one of the variables to be compared, Wilcoxon's test (nonparametric) was used. For correlation results, Pearson's correlation test was used. BMI was calculated with the formula weight (kg)/height (m)$^{2.}$

Statistical analysis was performed with IBM SPSS version 23.

RESULTS

The sample consisted of five men and eight women, with a mean age of 49 ± 15 years (min. 29 years, max. 73 years). Mean height was 1.69 ± 0.08 m (min. 1.59 m, max. 1.87 m). Mean weight was 74 ± 17.43 kg (min. 56 kg, max. 111 kg). Mean BMI was 25.51 ± 4.27 (min. 20.8, max. 34.6).

Aorta-psoas corridor

In the SD position, the aorta-psoas corridor or safe corridor at L1-L2 is distributed over a range of 2.02 cm (min. 0.15 cm, max. 2.17 cm), with an arithmetic mean of 1.25 ± 0.56 cm and a median of 1.39 cm. At L2-L3, it is distributed over a range of 1.63 cm (min. 0.99 cm, max. 2.62 cm), with an arithmetic mean of 1.66 ± 0.48 cm and a median of 1.72 cm. At L3-L4, it is distributed over a range of 1.4 cm (min. 0.9 cm, max. 2.3 cm), with an arithmetic mean of 1.56 ± 0.42 cm and a median of 1.58 cm. Finally, for L4-L5, it is distributed in the range of 2.23 cm (min. 0.19 cm, max. 2.42 cm), with an arithmetic mean of 1.03 ± 0.65 cm and a median of 1.00 cm.

When switching to RLD, the aorta-psoas corridor at L1-L2 is distributed over a 2.30 cm range (min. 0.37 cm, max. 2.67 cm), with an arithmetic mean of 1.68 ± 0.68 cm and a median of 1.83 cm. At L2-L3, it is distributed over a range of 1.67 cm (min. 0.90 cm, max. 2.57 cm), with an arithmetic mean of 1.82 ± 0.52 cm and a median of 1.78 cm. At L3-L4, it is distributed over a range of 1.46 cm (min. 0.98 cm, max. 2.44 cm), with an arithmetic mean of 1.69 ± 0.52 cm and a median of 1.54 cm. Finally, at L4-L5, it is distributed over a range of 2.32 cm (min. 0.24 cm, max. 2.56 cm), with an arithmetic mean of 1.26 ± 0.72 cm and a median of 1.33 cm.

Artery-disc distance

In the SD position, the artery-disc distance at L1-L2 is distributed over a range of 0.99 cm (min. 1.37 cm, max. 2.36 cm). At L2-L3, it is distributed over a range of 1.10 cm (min. 1.40 cm, max. 2.50 cm). At L3-L4, it is distributed over a range of 1.70 cm (min. 1.16 cm, max. 2.86 cm). Finally, at L4-L5, it is distributed over a range of 0.92 cm (min. 0.85 cm, max. 1.77 cm).

When positioning the patient in RLD, at L1-L2, the artery-disc distance is distributed over a range of 1.02 cm (min. 1.62 cm, max. 2.64 cm). At L2-L3, it is distributed over a range of 1.35 cm (min. 1.49 cm, max. 2.84 cm). At L3-L4, it is distributed over a range of 2.14 cm (min. 1.15 cm, max. 3.29 cm). Finally, at L4-L5, it is distributed in a range of 1.20 cm (min. 0.94 cm, max. 2.14 cm).

Aorta-psoas corridor in the supine vs. right lateral decubitus position

The statistical tests used to compare the two positions (SD and RLD) show that the aorta-psoas corridor presents statistically significant differences at the L1-L2 level (Student's t = -3.040; p = 0.010) between measurements taken in SD (mean = 1.25 cm) and RLD (mean = 1.67 cm). At L2-L3, no statistically significant differences were found (Student's t = -1.438; p = 0.176) between measurements taken in SD (mean = 1.66 cm) and RLD (mean = 1.81 cm). At L3-L4, there were also no statistically significant differences (Student's t = -0.941; p = 0.365) between measurements taken in SD (mean = 1.56 cm) and RLD (mean = 1.68 cm). At L4-L5, statistically significant differences were found (Student's t = -3.076, p = 0.010) between measurements taken in SD (mean = 1.03 cm) and RLD (mean = 1.26 cm).

Artery-disc distance in the supine vs. right lateral decubitus position

In the space between the artery and the intervertebral disc, no statistically significant differences were found at L1-L2 (Student's t = -6.629; p <0.0001) between measurements in SD (mean = 1.79 cm) and RLD (mean = 2.05 cm). For L2-L3, statistically significant differences were obtained between measurements in SD (mean = 1.86 cm) and RLD (mean = 2.05 cm) (Wilcoxon z-rank test = -2.483; p = 0.008). At L3-L4, there were statistically significant differences between measurements in SD (mean= 1.82 cm) and RLD (mean= 1.99 cm) (Wilcoxon z-rank test = -2.667; p = 0.008). Finally, at L4-L5, statistically significant differences (Student's t = -4.122; p = 0.001) were obtained between measurements in SD (mean= 1.23 cm) and RLD (mean= 1.46 cm) (Table 1).

Table 1. Values (in cm) of the aorta-psoas corridor and the artery-disc distance at different levels.

	Aorta-psoas corridor		Artery-disc distance	
	SD	RLD	SD	RLD
L1-L2	1.25 ± 0.56	1.68 ± 0.68*	1.80 ± 0,31	2.05 ± 0.37
L2-L3	1.66 ± 0.48	1.82 ± 0.52	1.86 ± 0.37	2.06 ± 0.50*
L3-L4	1.56 ± 0.42	1.69 ± 0.52	1.82 ± 0.54	1.99 ± 0.65*
L4-L5	1.03 ± 0.65	1.26 ± 0.72*	1.23 ± 0.28	1.46 ± 0.35*

SD = supine decubitus; RLD = right lateral decubitus.
*p <0.05

Correlation with BMI

Correlation analysis was performed using Pearson's or Spearman's correlation coefficient as appropriate. For this purpose, the assumptions of identical distribution, normality and independence were controlled. First, the null hypothesis was tested, which states that there is no linear association between BMI and corridor level, whereas the alternative hypothesis states that there is a correlation between the two variables. The strength of the association was described by rho. Interpretation of Pearson's and Spearman's correlation coefficient: 0.00-0.10 insignificant correlation; 0.10-0.39 weak correlation; 0.40-0.69, moderate correlation; 0.70-0.89 strong correlation; 0.90-1 very strong correlation. A p-value <0.05 was considered statistically significant. Statistical analysis was performed with R software version 1.2.5042© 2009-2020 R Studio, Inc.

The degree of association between BMI and corridor space obtained negative and positive results. In six associations, the results were negative, from -0.01 to -0.74, the lower the BMI, the greater the space of the corridors. In 10 associations, the results were positive, from 0.41 to 0.60, the higher the BMI, the greater the space of the corridors.

With the exception of the decubitus (L2-L3 space and L3-L4 space), supine aortic (L2-L3 space) and decubitus aortic (L2-L3 space) corridors that showed a p value <0.05 in the association with BMI, the null hypothesis of no linear association between BMI and the spaces of the other corridors is not rejected. Thus, 12 of the 16 associations are not correlated (p >0.05). Of the four spaces (L1-L2, L2-L3, L3-L4 and L4-L5) in each corridor, the one shown to have the highest correlation with the corridors was L2-L3, with an association between BMI and decubitus corridor of -0.59, supine aortic corridor of 0.60 and decubitus aortic corridor of 0.59. There was a moderate correlation between each of these three corridors and BMI (Table 2).

Table 2. Correlation values of body mass index and corridors.

		Corridor			
		Supine	Decubitus	Aortic supine	Aortic decubitus
L1-L2	p	0.08	0.96	0.05	0.10
	CCP	-0.49	-0.01	0.54	0.47
L2-L3	p	0.11	0.03*	0.03*	0.03*
	CCP	-0.46	-0.59	0.60	0.59
L3-L4	p	0.11	0.003*	0.05	0.13
	CCP	-0.45	-0.74	0.54	0.43
L4-L5	p	0.14	0.16	0.06	0.09
	CCP	0.42	0.41	0.52	0.47

PCC = Pearson's correlation coefficient; *p <0.05.

DISCUSSION

Several published studies analyze the changes that occur when the patient is placed in the SD and RLD positions. In 2016, Molinares et al.[31] analyzed 333 MRI scans of patients in the dorsal decubitus position and concluded that the size of the aorta-psoas corridor increases when the patient is placed in lateral decubitus. Zhang et al.[28] published contradictory results, reporting that the aorta-psoas corridor decreases when the patient is placed in the RLD position. The mobility of the psoas and the fixation of the abdominal aorta to the retroperitoneum play a fundamental role. Finally, Zehri et al.[32] conducted a study in which they evaluated corridors in 33 patients and concluded that size does indeed increase when going from SD to RLD, but it has no relationship with BMI or age. This last study coincides with the results obtained in our research.

Regarding the complications of the technique, Silvestre et al.[33] reported a rate of 11.2% in 179 patients with OLIF. Complications related to the approach were: iliac vein injury (3 cases), peritoneal tear (1 case), sympathetic trunk injury (3 cases), neurological deficit (2 cases), psoas muscle weakness or numbness (2 cases). In a retrospective study of 2998 LLIF cases between 2013 and 2015 that included 1003 OLIF cases, Fujibayashi et al.[34] published a complication rate of 15.3% for patients operated on with the OLIF technique. Abe et al.[35] conducted a retrospective study of 155 cases of OLIF. The complication rate was 48.3% and the three most frequent complications were: endplate fracture/subsidence (18.7%), transient psoas weakness and thigh numbness (13.5%), and segmental artery injury (2.6%). We believe that several of these injuries could be avoided if a correct study of the patient is carried out, accurately assessing the distance of the corridors.

One of the limitations of our study was the difficulty of evaluating patients with high BMI given the impossibility of performing the study in lateral decubitus due to the size of the patients and the physical dimensions of the scanner used. Therefore, we consider it important that further studies evaluating the corridor in a larger number of patients be carried out.

CONCLUSIONS

As stated in the objective of the study, significant changes occur in the aorta-psoas corridor and the artery-disc distance when the patient is positioned in RLD. However, these have no significant relationship with BMI. Therefore, surgical planning for the OLIF technique is inaccurate if the patient is only assessed using MRI in the SD position.

Conflict of interest: Dr. Enrique Gobbi is a spokesperson for NuVasive. The rest of the authors declare no conflicts of interest.

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