

Variation of conus medullaris location based on magnetic resonance imaging of the lumbar spine in Indonesia: A study at Dr Soetomo General Academic Hospital, Surabaya, Indonesia



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ABSTRACT

Introduction: Recognition of conus medullaris position, contains lumbosacral plexuses which supply motor and sensory innervation to the whole lower limb, pelvic and perineal areas, is critical to avoid injury due to lumbar procedures, such as spinal anesthesia and lumbar punctures. This study aimed to investigate the position of conus medullaris among Indonesians through magnetic resonance imaging (MRI) of the lumbar spine at Dr. Soetomo General Academic Hospital in order to minimize the risk of conus medullaris trauma.

Methods: A retrospective study was conducted to investigate the conus medullaris level and its correlation to gender and age Indonesian patients. The data were collected from lumbar MRI at Dr Soetomo General Academic Hospital during January 2020 and December 2021. The level variations of conus medullaris were recorded and determined as the highest, lowest and most common location descriptively.

Results: A total of 257 patients (126 male and 131 female) were included. The highest level of conus medullaris was in T11-T12 vertebrae (five patients). There were 12 patients in T12 vertebrae, T12-L1 in 86 patients, L1 in 62 patients, L1-L2 in 76 patients, and L2 in 12 patients. The lowest level was in between L2 and L3 vertebrae in 4 patients. Gender and age had no association with conus medullaris level.

Conclusion: The lowest level of conus medullaris was in between L2 and L3 vertebrae. The lumbar procedure such as punctures should be done below the L3 to avoid conus medullaris puncture trauma.

Keywords: Conus medullaris, spinal cord, lumbar procedure, spinal anesthesia.

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INTRODUCTION

The spinal cord is a network of nerves that extends from foramen magnum to the level of L1 with its terminal end is called conus medullaris.¹ In Asia, a study revealed that the conus medullaris position ranges from T12 to L2-L3 and mostly at L1 (52.4%).² The position matters in lumbar procedure, for instance, subarachnoid block or spinal anesthesia, an anesthetic technique used since the early 20th century. Currently, this technique is often used from cesarean section, orthopedic surgery to chronic pain management. After the injection, the anesthetic agent will occupy the subarachnoid space and inhibit nerve conduction below the injection site.^{1,3} In ambulatory surgeries, spinal anesthesia

with fast-acting local anesthetics has been favored over general anesthetics and associated with excellent patient satisfaction.⁴⁻⁶

Referring to the anatomy of the conus medullaris, lumbar procedure is often performed below L1 to prevent spinal cord injury. Such injury still occurs, leading to the urgency of investigating the conus medullaris position.⁷ A study in UK found 1 of 3900 cases of conus medullaris injuries following spinal anesthesia and 1 in 80,000 to 1 in 320,425 cases occurred as permanent injury.⁸

The spinal cord injury has been widely reported as manifested in paralysis of the femoral muscles, saddle numbness and urinary incontinence.^{2,7-9} In Indonesia, there was one report of drop foot after

spinal anesthesia.¹⁰ To avoid those risks following the lumbar procedure, we aim to provide a reference for conus medullaris positions, particularly among Indonesians, based on gender and age through lumbar magnetic resonance imaging (MRI) examinations.

METHODS

Study design and sample collection

This retrospective descriptive study consisted of 257 patients aged 18-85 (126 men and 131 women) whose lumbar spine was examined with MRI from January 2020 until December 2021. These samples obtained from inclusion and exclusion criteria. The inclusion criteria were patients over 17 years old and had readable

and good quality midsagittal lumbar MRI results, examined at Dr. Soetomo General Academic Hospital. Patients with the history of vertebrae trauma, spina bifida and tethered cord syndrome were excluded. The conus medullaris positions were recorded based on gender and age.

MRI evaluation

The lumbar MRI results were evaluated from the midsagittal section. The MRI was operated at xT or xT field strengths employing a specialized lumbar spine surface coil and a standard T1-weighted turbo spin echo MRI sequence. The slice was 3 mm thick. After obtaining a clear picture of the spinal cord, the midsagittal section was marked with a line by numbers 1 to 18. These lines indicated the intervertebral disc, the upper border, and the vertebral body's lower border. The result was evaluated through an axial section to determine which line the conus medullaris was located. The MRI data were retrieved from the Integrated Diagnostic Center, Dr Soetomo General Academic Hospital. The data were recorded and grouped according to gender and age. Two radiology experts retrospectively assessed all MRI results to reduce MRI misinterpretation.

Statistical analysis

The association between age and gender with conus medullaris position was statistically analyzed using the chi-square test. The statistics data were assessed with SPSS 17.0 (SPSS Inc., Chicago, IL, USA) and the association was considered significant at $p < 0.05$.

RESULTS

Out of 257 patients included in this study (male vs female, 126 vs 131), 36.9% of them had low back pain, followed by

tuberculous spondylitis (18.2%) and canal stenosis (17.5%). The fewest included diagnosis examined with MRI were bone

metastasis (7%) and neuropathy (8.5%) (Table 1). The conus medullaris position is mostly at T12-L1 ($n=86$), followed by

Table 1. Characteristics of patients included in the study ($n=257$).

Characteristics	n	%
Gender		
Female	131	51.0
Male	126	49.0
Age group (years)		
11-20	9	3.5
21-30	20	2.73
31-40	43	16.7
41-50	51	19.8
51-60	79	30.7
61-70	41	15.9
71-80	13	5.1
81-90	1	0.3
Diagnosis		
Low back pain	95	36.9
Tuberculous spondylitis	47	18.2
Canal stenosis	45	17.5
Hernia nucleus pulposus (HNP)	30	11.6
Neuropathy	22	8.5
Bone metastasis	18	7.0
Conus medullaris position		
T11-T12	5	1.9
T12	12	4.6
T12-L1	86	33.4
L1	62	24.1
L1-L2	76	29.5
L2	12	4.6
L2-L3	4	1.5

Table 2. Variation of conus medullaris position based on gender ($n=257$).

Conus medullaris position	Male, n (%)	Female, n (%)	Total, n (%)	p-value
T11-T12	0 (0.0)	5 (1.9)	5 (1.9)	0.180
T12	8 (3.1)	4 (1.5)	12 (4.6)	
T12-L1	40 (15.5)	46 (17.9)	86 (33.4)	
L1	28 (10.8)	34 (13.2)	62 (24.1)	
L1-L2	43 (16.7)	33 (12.8)	76 (29.5)	
L2	5 (1.9)	7 (2.7)	12 (4.6)	
L2-L3	2 (0.7)	2 (0.7)	4 (1.5)	

Table 3. Variation of conus medullaris position based on age groups ($n=257$).

Conus medullaris position	Age groups								p-value
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	
T11-T12	0	0	1	1	0	3	0	0	0.316
T12	1	3	4	3	1	0	0	0	
T12-L1	3	4	13	23	25	12	6	0	
L1	1	3	14	11	20	8	4	1	
L1-L2	4	10	7	10	27	16	2	0	
L2	0	0	3	2	4	2	1	0	
L2-L3	0	0	1	1	2	0	0	0	
Total	9	20	43	51	79	41	13	1	

L1–L2 ($n=76$) and L1 ($n=62$). The fewest conus medullaris position is L2–L3 ($n=4$ patients) (Table 1).

The potation variation of conus medullaris based on gender are presented in Table 2.

The 86 patients had conus medullaris positions between thoracic 12 (T2) and lumbar 1 (L1) (male vs female, 40 vs 46), 76 patients at L1–L2 (43 vs 33) and 62 patients at L1 (28 vs. 34). The conus medullaris positions of L2–L3 and T11–T12 were the fewest with the only observed in four patients (2 vs. 2) and five patients (0 vs. 5), respectively (Table 2). We found no significant relationship between the conus medullaris position and the gender of the patients ($p=0.180$).

The age group distributions of the patients are 51–60 years-old, 41–50 years-old, 31–40 years-old and 61–70 years-old group, by the number of patients are 79, 51, 43 and 41 people, respectively. The highest position of conus medullaris was at T11–T12 while the lowest one was at L2–L3 (Table 3). There is no significant association between the age of the patients and the location of conus medullaris ($p=0.316$).

DISCUSSION

Several medical procedures such as subarachnoid block, epidural anesthesia and lumbar puncture, must be carried out carefully by being cautious to the anatomy of the spinal cord in order to prevent punctures on conus medullaris. Conus medullaris trauma may cause several complications, such as pain,^{11,12} sexual dysfunction,^{12,13} urinary incontinence,^{11,12} paraplegia,¹⁴ paresthesias,¹² drop foot,^{11,15,16} and spinal cord ischemia.⁸ Although the aforementioned symptoms are mostly temporary, several studies reported that permanent complications can also occur.^{8,15} The incidence of drop foot and hypoesthesia typically resolve within a few months, but loss of sensory and motor abilities, urinary tract dysfunction, hypoesthesia, and gait imbalance typically improve within a few weeks.^{17,18} Complaints that arise permanently are usually pain, paresthesia, and hypersensitivity.¹⁸

A study regarding conus medullaris position in Indonesia has ever been done

in a fewer amount of samples ($n=135$).¹⁹ Some other countries that conducted similar study were UK ($n=504$),²⁰ South Korea ($n=187$),² Japan ($n=379$),²¹ the US ($n=585$),⁷ Lebanon ($n=141$),²² India ($n=100$),²³ Nigeria ($n=177$)²⁴ and Turkey ($n=341$).²⁵ We found no significant relationship between gender and conus medullaris position, as also revealed in another study in Indonesia¹⁹ and other studies in various countries ($p>0.05$).^{20–22,24,26–32}

The conus medullaris positions are mostly located at L2–L3 or L3–L4, but there is still a risk of conus medullaris injury when performing spinal anesthesia.¹ The highest position of conus medullaris in this study are T11–T12 ($n=5$) (Table 2), which was similar as determined in two studies from Turkey.^{32,33} The locations of conus medullaris in this study are at T12–L1 ($n=86$, 33.4%, 40 men and 46 women), L1–L2 ($n=76$, 29.5%, 43 men and 33 women) and L1 ($n=62$, 24.1%, 28 men and 34 women). The results of this study are slightly different from the previous ones where mostly the position of conus medullaris is L1 as in South Korea (52.4%),² England (54%),²⁰ Turkey (45%),³² US (49%),⁷ Japan (58.7%),²¹ Lebanon (54.6%),²² Nigeria (62%),²⁴ India (63%),²³ and Indonesia (59%),¹⁹ but only 24.1% in this study. The conus medullaris level of T12–L1 was also commonly found in a study from Turkey (28%) and Japan (14%).^{21,33}

The lowest position of conus medullaris in this present study was L2–L3 ($n=4$), as also reported in previous studies.^{34,35} Based on this finding, it is recommended that spinal procedure should be performed at L3–L4 or L4–L5, as also mentioned in previous studies from South Korea and US.^{34,35} This result differs from another Indonesian study that found L2 as the lowest position.¹⁹ Several previous studies suggested that L3 was the lowest position of conus medullaris.^{7,25,34}

The age range of included patients in this study was 18–52 years (Table 3). The age of patients included in this study is similar to previous ones in Indonesia and India that targeted the age ranged 18–65 years,^{19,23} 16–85 years in UK²⁰ and 20–74 years in US.⁷ This study found no

relationship between age and the location of the conus medullaris which is similar to previous findings.^{7,24,28}

Variation of conus medullaris position in existing studies are different from some textbooks. In textbooks, the average level of conus medullaris is L1,^{36–40} L1–L2^{41–43} and L2,⁴⁴ which means that the spinal puncture should be done below L1. Other textbooks explicitly specified that the spinal procedure should be performed below L1 or L2.^{1,45}

Differences in conus medullaris position may be due to variety of patients demographics, patient diagnosis and inclusion and exclusion criteria for each study. In a study conducted to European population, samples with clinical diagnosis of bone metastases and spinal trauma were included, whereas another study with a similar population excluded them.^{7,20} Some studies also did not include the clinical symptoms of the patients.^{19,22,23}

To prevent conus medullaris injury, performing lumbar MRI before every lumbar procedure is not effective. The risk of procedure related to the variations of conus medullaris position also needs to be explained to patients prior to the procedure. The results of this study are expected to be used as a reference for spinal anesthesia especially in Indonesia.

CONCLUSION

Variation in the conus medullaris position Indonesian samples ranges between T11–T12 and L2–L3. The conus medullaris is mostly located at T12–L1, followed by L1 and L1–L2. The least frequent of conus medullaris locations is at L2–L3. The location of conus medullaris is not influenced by age and gender. To avoid conus medullaris punctures, lumbar procedures should be initiated at L3–L4 or L4–L5.

ETHICAL APPROVAL

The Dr Soetomo General Academic Hospital, Indonesia (No. 0551/LOE/301.4.2/VIII/2021) approved the study protocol.

COMPETING INTERESTS

All authors declared no conflict of interest.

GRANT INFORMATION

This study received no external funding.

AUTHORS CONTRIBUTION

AA contributed in concepting and designing the study, literature search, data collection, data analysis, manuscript preparation and editing. CSW, BW, and ER were responsible in concepting and designing the study, contributed in intellectual content, manuscript editing and final editing.

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