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Research Article

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Accuracy of Transforaminal L4 Epidural Injection by Ultrasound Confirm By Fluoroscopy and Dye Injection

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Abstract: **Background:** Transforaminal nerve root injection of L4 is part of the management of low back pain caused by radiculopathy. This study was determined the accuracy and successful rate of ultrasound guided lumber transforaminal epidural injection which was validated by conventional fluoroscopic technique. **Aim:** the aim of study to determine the accuracy of needle position under US guidance and confirmed with fluoroscopy in patient who subject transforaminal nerve root injection. **Patient and Method:** A total of 20 patients with L4 disc prolapse causes radiculopathy were recorded. Using transforaminal route , the needle position was detected by axial and longitudinal view of the ultrasound with fluoroscopic conformation .We detected the needle position accuracy of ultrasound guided lumber transforaminal injection approach. **Result:** The successful rate of ultrasound guided interventions was 95% as confirmed by fluoroscopy. There was only one failed case in the ultrasound guided. **Conclusion:** Ultrasound guided lumber transforaminal epidural injections are accurate and practical in clinical cases with successful rate of 95%. US guidance has decreased radiation exposure and decreased need of operative room to significant level in this study.

Keywords: Transforaminal injection ,Radiculopathy ,Ultrasound guidance.

INTRODUCTION

Low back pain is defined as lumber spinal pain or sacral spinal pain or any combination of the two (Merskey, H. 1994). Low back pain is also defined as pain and discomfort ,localized below the costal margin and above the inferior gluteal folds ,with or without leg pain(Van Tulder, M. *et al*., 2006).

Pain caused by a herniated disk classically increases by bending forward, sitting, coughing, or (excessive) stress on the lumbar disks and can be avoided by lying down or sometimes by walking. Inversely, pain from a lumbar spinal canal stenosis can typically increase when walking and improve immediately upon bending forward. In addition to the pain, the patients also often report paresthesia in the affected dermatomes.

Low back pain can be classified depending on the duration into acute low back pain persisting for less than 6 weeks, Sub-acute low back pain persisting between(6 and 12 weeks) and chronic low back pain persisting for 12 weeks or more. Pain generator may change as the pain becomes chronic and longstanding.

Low back pain need not be restricted to lumbar and sacral regions.
Pain can be referred to other regions, most commonly lower limbs.
Referred pain is pain perceived in a region innervated by nerves other than the nerves that innervate the actual source of pain(Fishman, S. M. 2012).

The upper lumbar facet joint pain may be referred to flanks, hips and lateral thigh, whereas pain from the lower lumbar facet joints are referred to posterior thigh. Facet joint pain is rarely referred below knee'(Van Kleef, M. *et al*., 2011).

Similarly pain from sacroiliac joint may be referred to lower lumbar region, lower limbs and rarely to the foots (Vanelderen, P. *et al*., 2011). Patients with degenerative disc disease (not disc prolapse) have axial back pain which can be referred to anterior thigh (L3-4 disc), lateral thigh (L4-5 disc) and posterior thigh (L5-S1)(Kallewaard, J. W. *et al*., 2011).

A standard U/S device with a broadband curved array transducer working at (3-8 MHZ). Placed a patient in prone position and pillow was placed under abdomen to reduced lumber lordosis and allow a more comfortable position. A sagittal scan is performed using a curvilinear 40- to 60 mm transducer starting from the midline at the upper sacrum. Sliding the transducer more cephalad and shifted medially without tilting it until superficial echo signals of the L5 spinous process and S1 median crest are visible. The transducer may be advanced in the cephalad direction to identify L4 lumbar spinous process. Sliding the transducer paramedial will initially result in the appearance of

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a deeply located "saw tooth" signal of the articular processes, followed by the "trident sign" of the transverse processes. The psoas muscle is seen between the transverse processes, with the hyperechoic PAP at the superficial plane of the muscle containing exiting nerve root and blood vessels. Then the axial scan is performed, starting from the superficial sacrum, the transducer should be moved cephalad Once a solid hyperechoic signal of the sacral surface has vanished, the L5-S1 interspinous acoustic window is visible. At times, all elements of the intrathecal compartment are seen, including the ligamentum flavum, dorsal dura, cerebrospinal fluid and ventral dura. More frequently, only some of these structures are visible. More cephalad scanning will reveal an anechoic signal of the L5 spinous process and lamina. At the level of spinous processes and laminae, the deep tissue plane is presented by the lateral boundaries of the foramina and the posterior lateral part of the vertebral body or the intervertebral disk (Waldman S. D. 2014) .

AIMS OF THE STUDY

To determine the accuracy of needle position under US guidance and confirmed with fluoroscopy in patient who subject transforaminal nerve root injection.

Patients and Methods

Cross sectional study was performed on 20 patients in the pain management unite of Baghdad medical city from November 2019 till December 2020.Study population were all patients with low back pain causing radiculopathy referring to department of pain whose diagnosis were previously confirmed by MRI and were selected to undergo lumber transforaminal epidural injection .Study protocol was reviewed and approved by the institutional review Iraqi board of medical city.

Inclusion criteria:

- Patient with low back pain treated conservatively or with radiculopathy correlating with MRI finding of disk prolapse.
- Age from 30-80 yrs old from both gender.
- Hight from 160-180 cm and weight from 60 to100 kg.
- ASA score l and ll.
- Patient with local or systemic infection; spinal stenosis, central disc herniation with axial pain, herniated degrative disc, spinal deformity, and vertebral fracture.

Exclusion criteria:

- Patient refusal
- Coagulopathy disorder.
- History of allergy to local anesthetic (lidocaine) and contrast dye.
- Previous spinal surgery or deformity.
- Pregnant or lactation female patient.

For all patients, standard monitoring (noninvasive blood pressure, pulsed oximetry, ECG). IV cannula was done.

The patient was placed in the prone position, a pillow is put under the abdomen to reduce lumbar lordosis . A 3–8 MHz curvilinear US probe is utilized to perform the procedure .

Following the sterile technique ,the US transducer was insured in sterile coating and sterile US gel was apply on the patient sterile skin . A 22 – Gauge, 3.5 inch, Quinke-tipped spinal needle was applied for all injections .

Starting at the sacrum, longitudinal scanning begins with the transducer positioned at the midline view (Fig.1), skin marking can be done with a pen alongside the transducer to support localize spinal levels and provide "reference points" of anatomic structures. Once the longitudinal midline images are obtained, the transducer is gently moved laterally until a "saw tooth" hyper echoic line is seen (Fig.2).

Figure (1) Left: midline position of the transducer (semitransparent red rectangle). Right : sonographic long axis view of the lumbar spine showing the L4 and L5 spinous processes, the median S1 crest(SC), the hyperechoic lines of dorsal (DD) and ventral dura (VD), and the hypoechoic intrathecal (IT) space.

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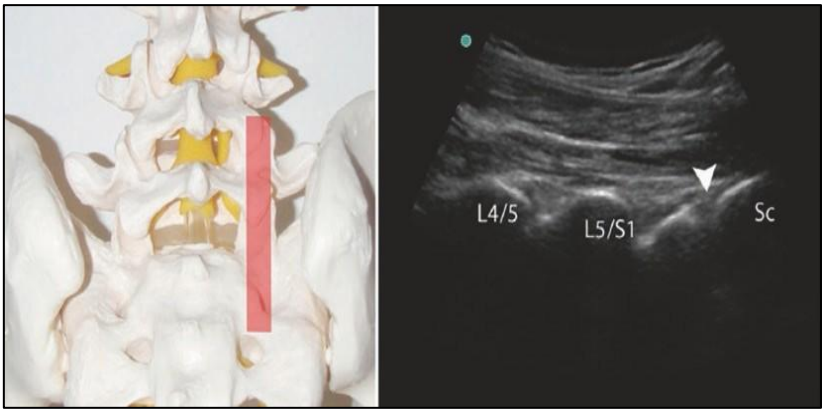
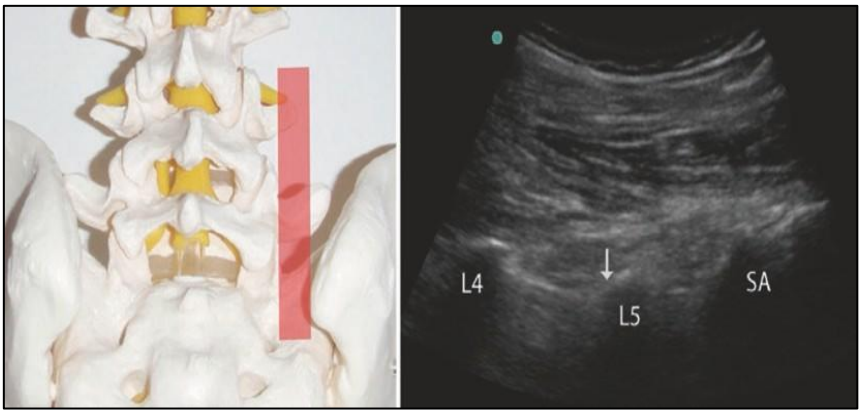


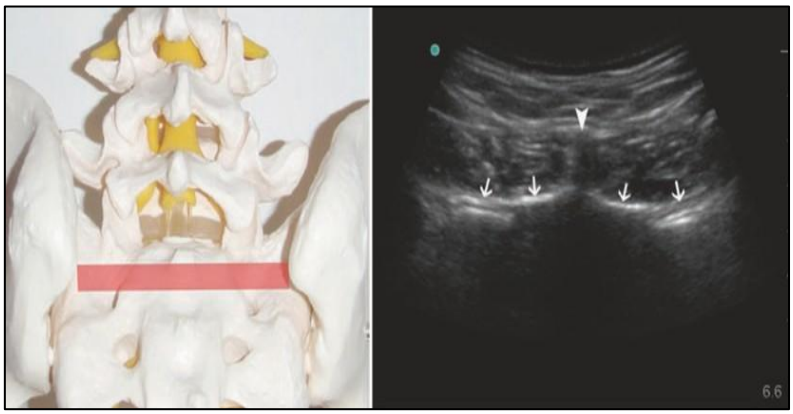
Figure(2) Left : paramedian position of the transducer (semitransparent red rectangle). Right: sonographic long –axis view of the lumbar spine with the L4/L5 and L5/S1 zygapophysial joint contours and the S1 (arrowhead) dorsal foramen . The joint gap is not visible in this view .

This bony structure explain the superior and inferior articular process, these are the transverse processes with the hypo echoic soft tissue between them (Fig.3).



Figure(3) Left: lateral position of the transducer (semitransparent red rectangle). Right :sonographic long –axis view showing the L4 and L5 and the sacral ala(SA).Upper edge of the transverse process or the sacral ala ,immediately lateral to the superior articular process(arrow)is the correct anatomical target .

Axial (short-axis) sonography is applied at the sacrum . The first distinct midline bony protuberance is the S1 median crest of the sacrum (Fig.4).



Figure(4)Left: Axial position of the transducer (semitransparent red rectangle).Right :sonographic short –axis view of the sacrum showing the S1 median crest (arrowhead) and the hyperechoic surface (arrows)of the sacrum .

The transducer is then moved cephalad until a deep hyperechoic structure is seen. This normally represents to the L5/S1 intrathecal space (Fig.5).

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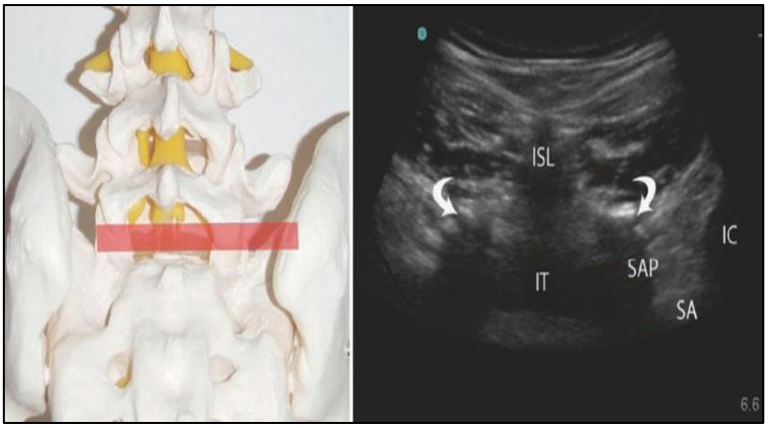
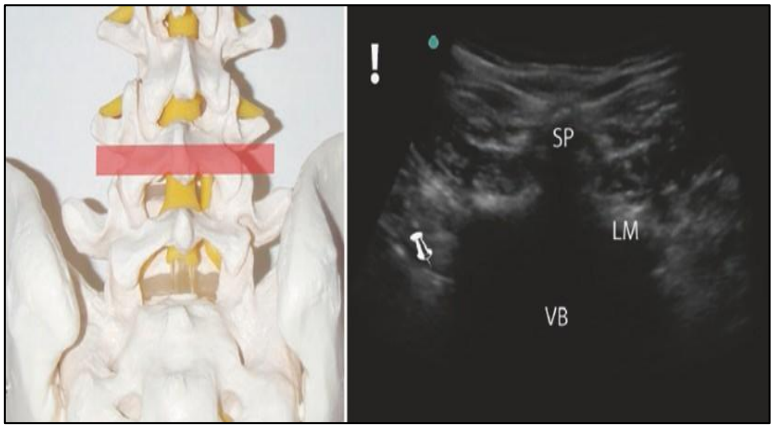
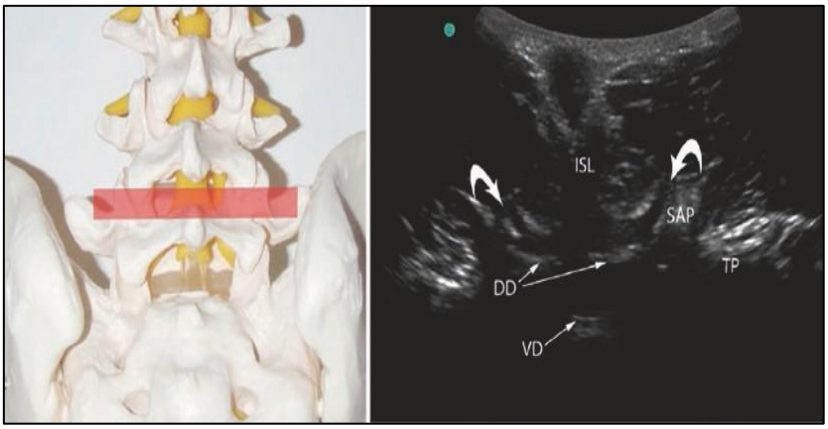


Figure(5) Left: axial position of the transducer (semitransparent red rectangle). Right :sonographic short – axis view of the lumbosacral segment showing the hypoechoic L5/S1 interspinous ligament (ISL), the L5/S1 zygapophysial joints (curved arrows), the intrathecal (IT)space, the S1 superior articular process (SAP), the sacral ala (SA), and the iliac crest (IC).

Next midline hyperechoic signal, cephalad to the intrathecal space, is the L5 spinous process. At any lumbar level, two axial views can be obtained the "interlaminar window" (Fig.6), and "the spinous process/lamina window" (Fig.7).



Figure(6) Left : axial position of the transducer (semitransparent red rectangle). Right : sonographic short – axis view of the L4 –vertebra (bone window).L4(SP) spinous process and L4 lamina (LM) are completely shadowing the L4 vertebral body (VB). Intrathecal space and the transverse process are not visible at this view. Exiting L4 nerve root is seen on the left (pin arrow).



Figure(7)Left : axial position of the transducer (semitransparent red rectangle). Right : sonographic short-axis view of the L4/L5 segment showing the hypoechoic L4/L5 interspinous ligament(ISL), THE L4/L5 zygapophysial joints (curved arrows), the dorsal (DD) and ventral dura (VD), the L5 SAP, and the L4 transverse process (TP).

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It is continue cephalad scanning and identify all lumbar spinous processes and correlate those with the previously performed skin marking.

When the transducer is firmly positioned at the desired level, a three-step shadow of the lumbar vertebra will appear: the most superficial hyper echoic structure is the interspinous ligament or the spinous process, with the zygapophysial joint positioned just inferiorly and lateral to it and the transverse process located further inferiorly and laterally. The spinal needle was inserted just lateral to the US probe and inserted at the optimal site. The fluoroscopy was taking in AP and lateral view to confirm the success of correct position of tip of needle (the needle should be lateral between 2 pedicle) and dye was injected to confirm that there is no intravascular or intrathecal spread and to show the dye spread in epidural space or to show the anatomy of nerve in AP and lateral view under fluoroscopy guidance .If successful so proceed the procedure if not may need simple manipulation either under the guidance of US , if under US regarded US as a second trial , if not successful so third trial by US was done for the patient . In case of failure ,reposition of needle was done by the guidance of fluoroscopy.

The main outcome of the study was to assess the accuracy of US in needle position under the guide of US in transforaminal area. Accuracy of spinal segment integrity and pattern of radiopaque contrast spread were determined.

Statistical Analysis:

- A total of 20 patients going through L4 trans-foraminal nerve root injection were the subjects of this study.
- IBM SPSS version 26 was used for this study statistical analysis
- Participant characteristic data are presented as mean, SD and percentages.
- Chi-square test was used to test association between study group characteristics (P-Value = 0.05).
- Fisher exact test was used to test the association between U/S and fluoroscopy approaches (P-Value = 0.05).
- One sample t test was used to compare U/S approach number of images mean with the minimum image requirement for fluoroscopy approach (12 images); null hypothesis (no significant difference between U/S approach number of image required and fluoroscopy approach number of image required), alternative hypothesis (there is significant difference between U/S approach number of image required and fluoroscopy approach number of image required) (P-Value = 0.05).

Independent samples t test were used to assess the mean difference among general characteristics factors (P-value =0.05).

One way ANOVA test were used to assess the mean difference among general characteristics factors (P-value =0.05).

Pearson's correlation was used to assess the correlations between U/S trials, number of fluoroscopy images ($R \geq \pm 0.3$ P value=0.05).

RESULTS

The demographic data that was collected are (illustrated in table 1):

- Age: the mean age of the study group was 50.45±14.78 years.
- Gender: male to female percent was 55:45 percent as illustrated in figure 8.
- Weight: the mean weight of the patients was 87.15±10.95 kg.
- Height: the mean height of the patients was 169.45±9.28 cm.
- Body mass index: the mean BMI of the study group was30.28±2.19 kg/m^2.
- Ultrasound approach trials: the mean of the U/s Approach trial was 1.45±.69 trials.
- Number of fluoroscope images: the mean of fluoroscopy images was 3.50±2.42 images.
- Difficulty of U/S approach: the proportions of difficult and non-difficult cases were 25% and 75% respectively as illustrated in figure 9.
- Ultrasound Approach: 95% of the U/S approach was eventually successful and only 5% failed as shown in table 2.
- Fluoroscopy Approach: the fluoroscopy procedure steps (AP Fluoroscopy, AP dye, Lateral view fluoroscopy and Lateral view dye) were successful in confirming the success of 95% of the U/S approach as shown in table 2.

Table 1: Description of the study group characteristics

N=20	Mean ±SD	Minimum -Maximum
Age	50.45±14.78	30.00 -80.00
Weight	87.15±10.95	60.00 -100.00
Height	169.45±9.28	160.00 -180.00

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BMI	30.28±2.19	23.44 -33.20
U/S Trials	1.45±.69	1.00 -3.00
Number of images	3.50±2.42	2.00 -12.00

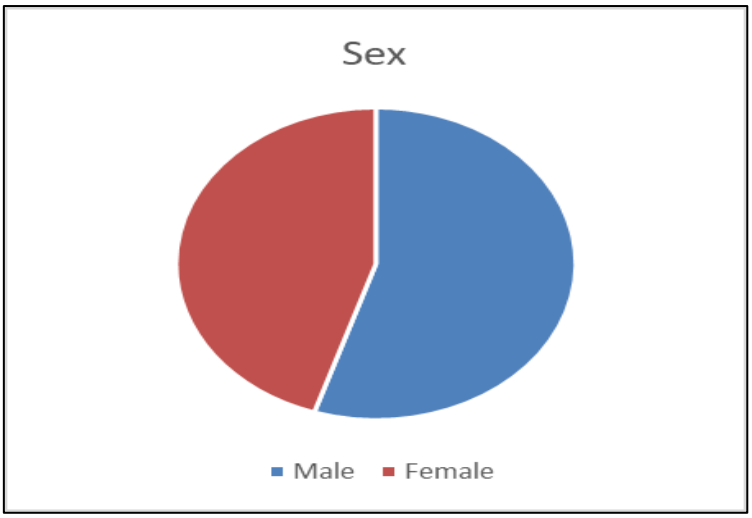

Figure 8: sex distribution in study group.

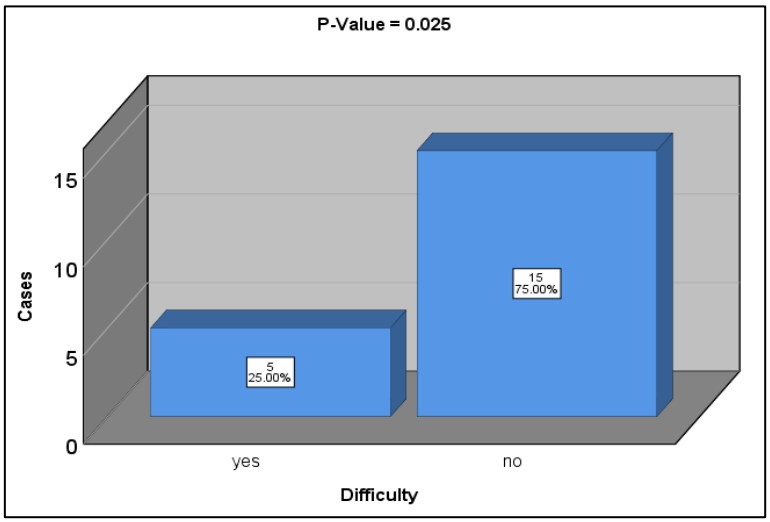

Figure 9: U/S approach difficulty distribution of the study group.

Table 2: number of successful and failed cases

N=20	U/S Approach		P value
	Successful	Failed	
Collectively succeeded U/S approach confirmed by fluoroscopy	19(95%)	1(5%)	0.001*

There was significant association between U/S approach success and the fluoroscopy steps confirming success (P-Value = 0.001) as shown in table 3.

There was significant positive correlation between U/S approach trials and number of fluoroscopy images(R= 0.587 ,P= 0.007 as illustrated in figure 10.

Table 3.3 : Association between U/S approach success and the fluoroscopy steps confirming success

N=20	U/S approach		P-Value
	failed	successful	
AP Fluoroscopy conformation	1	19	0.001*
AP dye conformation	1	19	0.001*
Lateral view fluoroscopy conformation	1	19	0.001*
Lateral view dye conformation	1	19	0.001*

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*Fisher exact significant P-Value <0.05

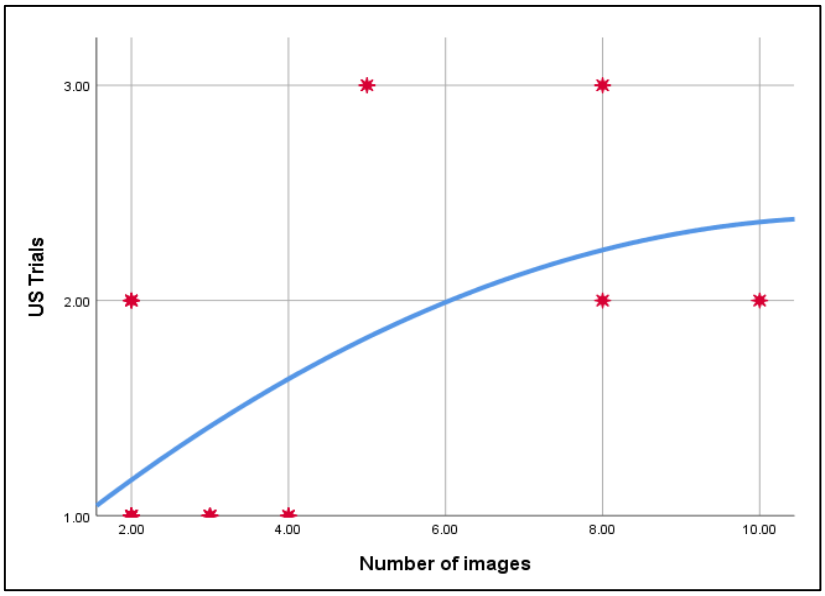

Figure 10: Pearson correlations between U/S approach trials and number of fluoroscopy images.

Difference in U/S approach trials among certain study group characteristics Described in (table 4)

- U/S approach: U/S trials were significantly higher in failed U/S approach (mean 3, P-Value = 0.016) as illustrated in figure 11.
- Gender: no significant difference of U/S trials mean between male and female (P-Value = 0.210) as illustrated in figure 12.
- Age group: no significant difference of U/S trials mean between different age groups (P-Value = 0.249).
- Weight group: no significant difference of U/S trials mean with different weights (P-Value = 0.567).

Table 4 : Difference in U/S approach trials among certain study group characteristics

N=20		U/S Trials Mean	P-Value
U/S approach	Failed	3.00	0.016*
	successful	1.37	
Gender	Male	1.27	0.210
	Female	1.67	
age group	30-49 years	1.70	0.249
	50-69 years	1.25	
	≥70 years	1.00	
weight group	60-79 kg	1.67	0.567
	80-100 kg	1.41	
*significant P-Value <0.05			

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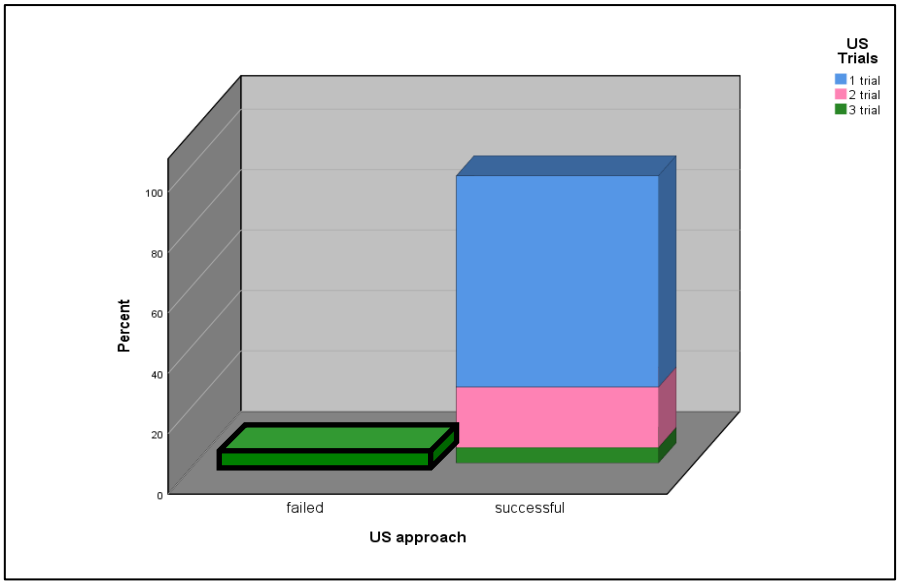

Figure 11: distributions of U/S trials among U/S approach.

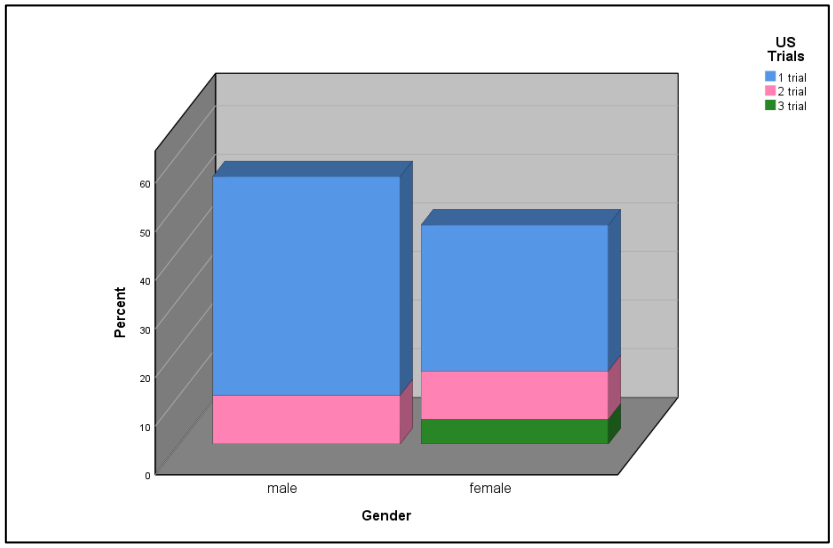

Figure 12: distributions of U/S trials among Gender.

Association of U/S approach difficulty and certain study group characteristics Described in (table 5)

- U/S approach: no significant Association between U/S difficulty and U/S approach success (P-Value = 0.076).
- Gender: no significant Association between U/S difficulty and gender (P-Value = 0.210)
- Age group: no significant Association between U/S difficulty and different age groups (P-Value = 0.249).
- Weight group: no significant Association between U/S difficulty and different weights (P-Value = 0.567).

Table 5 : Association between U/S approach difficulty and certain study group characteristics

N=20		Difficulty		P-Value
		Yes	no	
		Count	Count	
US approach	Failed	1	0	0.076
	successful	4	15	
	Total	5	15	
Gender	Male	3	8	0.795
	Female	2	7	
	Total	5	15	

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age group	30-49	4	6	0.104
	50-69	0	8	
	=>70	1	1	
	Total	5	15	
weight group	60-79	1	2	0.718
	80-100	4	13	
	Total	5	15	

Difference of number of images mean between U/S approach and fluoroscopy approach and study group characteristics Described in (table 6)

- The number of images (mean =3.5) required in U/S approach was significantly lower than the number of images required in the fluoroscopy approach (minimum 12 images) with (P-Value = 0.001).
- Gender: there was no significant difference in mean of images between male and female (P-Value = 0.929) as illustrated in figure 13.
- Age group: 30-49 years old patients required significantly higher number of images (P-Value = 0.025) as illustrated in figure 14.
- Weight group: there was no significant difference in mean of images with different weight group (P-Value = 0.379) as illustrated in figure 15.

Table 6 : Difference of number of images mean between U/S approach and 12 images as a minimal number of fluoroscopy approach and study group characteristics

N=20		Mean	P-Value
U/S Approach number of images mean		3.50	0.001*
Gender	Male	3.55	0.929
	Female	3.44	
Age group	30-49 years	4.90	0.025*
	50-69 years	2.13	
	≥70 years	2.00	
Weight group	60-79 kg	4.66	0.379
	80-100 kg	3.29	
*significant P-Value <0.05			

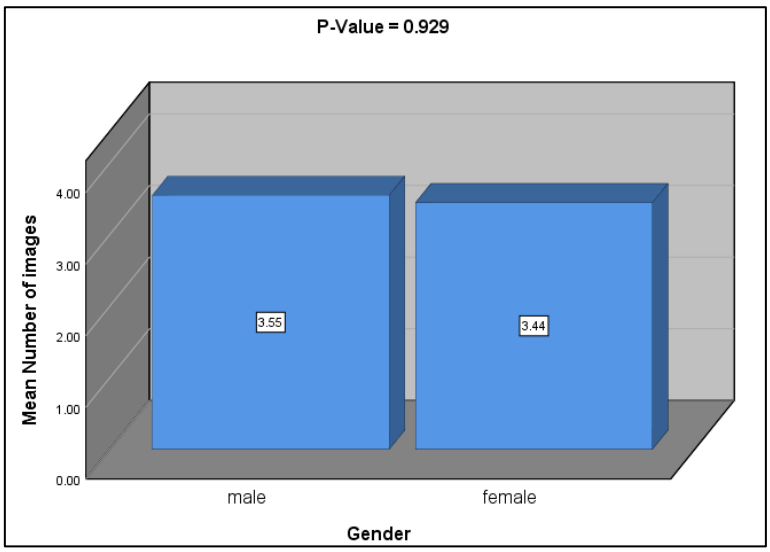

Figure 13: difference of mean number of images between male and female.

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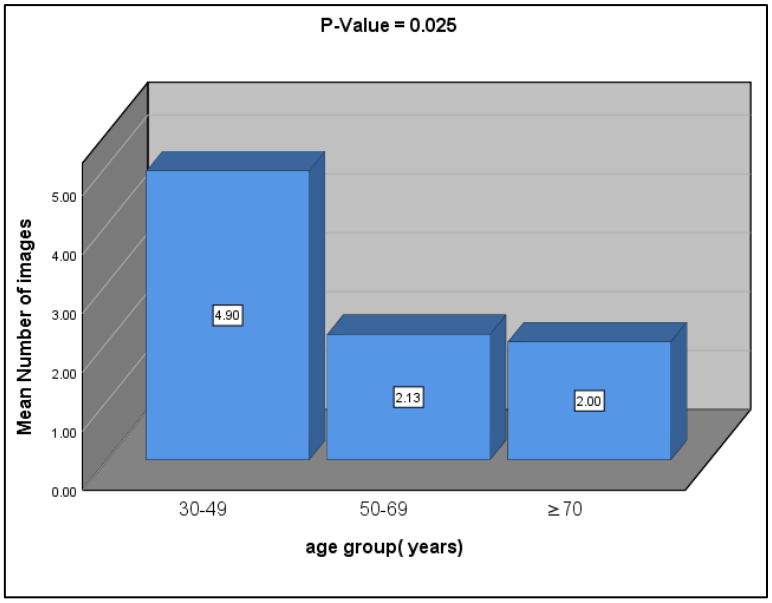

Figure 14: difference of mean number of images between different age groups.

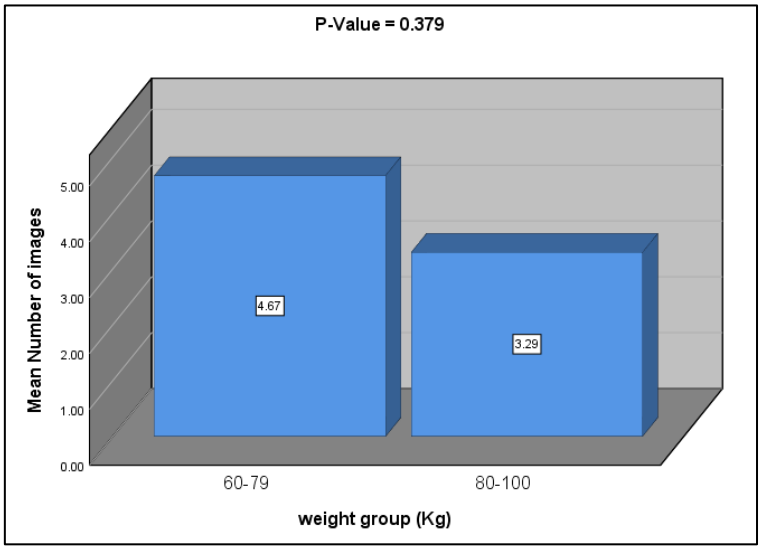

Figure 15: difference of mean number of images between different weight groups.

DISCUSSION

Transforaminal epidural injection is useful in treatment of lumber radicular pain. The conventional fluoroscopic guidance is commonly performed with contrast injection to confirmed accuracy of injection by define needle tip for desired and correct position. The disadvantage of fluoroscopy is radiation exposure risk, US detect the anatomical target and makes it feasible to performed TFEI while elimination exposure to radiation. A numbers of reports showed that ultrasound guidance in lumber spinal procedure is a possible but difficult technique (Liu, S. S. *et al*., 2010).

Although the spinal bony anatomical detection of lumber region is unwell detected by ultrasound , under the low frequency of ultrasound probe ,it feasible to detect lumber spinal anatomy. Lumber TFEI is related with lower risk of dural puncture and best efficacy on pain relief, compared to posterior median and Para median injection approaches. (Bohannon, D. S. 2009)

The mean age of patients was 50.45± 14.78(30-80) years old in which The mean weight of them was 87.15 ±10.95 kg and the mean height was 169.45±9.28 cm .Nine of patients were female (45%) and Eleven patients were male (55%), P-Value (0.025), in which only 5(25%) of all patients were difficult to this procedure and, number of collectively succeeded US approach confirmed fluoroscopy are 19 (95%) with (P- Value 0.001). There was strong attachment between success ,trials and number images between US approach and fluoroscopic approach with P- Value (0.001)

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,(0.007) respectively ,in which US trails more in failed US approach (mean 3,P-Value 0.016) ,and number of images that needed in US approach was significant minimal than that needed in fluoroscopy approach (12 images) with P- Value 0.001,so it benefit to decrease time exposure of radiation ,but age group (30-49) years old patients needed significantly more number of images (P-Value 0.023), while gender and weight group on significant difference in mean of images (P-Value 0.92,P-Value 0.37) .There were not specific association between US difficulty with US approach success ,gender, age, and weight (P-Value 0.076, 0.21, 0.24, 0.5) respectively. In the one failed cases, the needle tip was incorrected position therefore the needle had to be repositioned but still failed .No complication were noted.

In this study, we can localize transforaminal space in 95%(19) cases and only 5% (Merskey, H. 1994) case was failure to transforaminal space (lower No. of failure) when compared with Dinesh Kumar sahu *et al* that found more number of cases(Sahu, D. K. *et al*., 2016) and The successes ratio in current study was up to 95% with no serious complication and no significant difference in age, there were higher successful when compared with Yang *et al* that found successes ratio 87.9% because physicians are more experience (Yang, G. *et al*., 2016).

This study are no significant difference between difficulty and US guidance that disagree with Chumananvej *et al* that successful ratio are lower than in this study because SNRB reported that facet echo edge was identified by US ,It is not easy to have clear view for facet echo in all patients and it is difficult to place the needle tip at facet echo edge under us , we think that is causes for their lower successful ratio because the nerve root is deep within the foramina and it cannot be visualized under us guidance. In current study, that was no significant difference between gender and with us difficulty that agree with sorayouth Chumnavanvej because low frequency of us are uses ,it feasible to identify lumber spinal anatomy , but there were no significant associated between US difficulty and different age group ,that disagree with Sorayouth Chumnavanvej MD that found degeneration and osteophyte of spine in older age cases detoriation of US identification when compared to some younger patients (Chumnanvej, S. *et al*., 2011).

In this study, The dye spread to confirmed successful ratio are used that agree with Preeti Soni *et al* because presence of dye in ventral intraformational space confirm the position of needle and contrast spread under fluoroscopy guidance. (Soni, P., & Punj, J. 2020)

CONCLUSION

Accuracy of transforaminal epidural injection of L4 can be performed under US guidance although fluoroscopic conformation is needed. US guidance has decreased radiation exposure and decreased need of operative room to significant level in this study.

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