Preprocedural Ultrasonography Versus Landmark-Guided Spinal Anesthesia in Geriatric Patients with Difficult Anatomy: A Prospective Randomized Trial

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ABSTRACT

Objective: This study was aimed to determine whether preprocedural ultrasonography (USG) affects the technical performance of spinal anesthesia in elderly patients with difficulty in palpating landmarks, scoliosis, or previous spine surgery.

Materials and Methods: This prospective study was conducted in 156 elderly patients scheduled for elective orthopedic lower extremity surgery. The patients were randomly divided into 2 groups to receive spinal anesthesia by the preprocedural USG examination (group U) or conventional landmark palpation technique (group P). The primary finding of our study was the rate of successful access to the subarachnoid space on initial needle insertion attempt. Secondary achievements included number of needle insertion attempts, number of needle redirections, total procedure time, needle pain scores, patient satisfaction, and complications of spinal anesthesia.

Results: The rate of successful access to the subarachnoid space at the first needle insertion attempt was significantly higher in group U than in group P (74.4% vs 53.8%, p=0.008). Medians (interquartile range) of both needle insertion attempts (group P, 2 [1-3] vs group U, 1 [1-2]; p=0.038) and needle redirections (group P, 3 [2-5] vs group U, 2 [1-4]; p=0.028), requiring to achieve dural puncture, were significantly higher among the patients in group P than those in group U. No statistically significant difference was found between the groups regarding total procedure time, pain scores, patient satisfaction scores, and spinal anesthesia-induced complications (p>0.05).

Conclusion: Our study findings showed that preprocedural neuroaxial USG improves technical performance of spinal anesthesia in elderly patients with difficult anatomy.

Keywords: Anesthesia, spinal, ultrasound imaging, geriatrics

Introduction

Central neuroaxial blockade has traditionally been based on the determination of the appropriate interspinous space and needle insertion point by palpation of the anatomical landmarks (iliac crista and spinous process). However, obesity, lumbar spine abnormalities, and previous spinal surgery are the causes that make the landmark-guided spinal anesthesia difficult [1-3]. In addition, degenerative changes related to aging, ossification of interspinous ligaments, hypertrophy of the facet joints, and narrowed interspinous spaces may increase the rates of failures in spinal anesthesia [1-4]. Such challenges can cause many complications, such as multiple attempts of the puncture and risks of needle trauma (epidural/spinal hematoma, neural damage, and post-dural puncture headache) [5-7].

Ultrasononography (USG) examination before spinal anesthesia enables accurate determination of the midline and intervertebral levels and measurement of the depth of intrathecal space [1, 2, 8]. Although the use of USG has commenced a new era, especially in the peripheral nerve and facial plane blocks, it is yet to gain the same popularity in neuroaxial block procedures as the more widely used and popular regional anesthesia technique because neuroaxial blocks applied by experienced practitioners have higher success and lower complication rates in individuals with a normal anatomy [9, 10]. In addition, the use of USG is limited and requires experience owing to the narrow acoustic windows resulting from the traditional spinal bone structure [10, 11].

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Contradictory results have been obtained with the use of USG in spinal anesthesia in the general population. In some studies, compared with the landmark-guided technique, the use of traditional preprocedural USG was reported not to provide a significant advantage [12-14]. In contrast, USG scanning is associated with reduction of the risk of failure and a lower number of needle passes in patients with expected technical difficulties [15-19]. We assumed that spinal anesthesia was relatively more difficult in both elderly patients and those with abnormal anatomical landmarks. Therefore, because the number of studies investigating this issue are limited, there is still a need to study the effectiveness of USG in patients of different age groups with different characteristics.

The objective of this study was to determine whether the preprocedural USG affects the technical performance of spinal anesthesia in elderly patients with difficulty in palpating landmarks, scoliosis, or previous spine surgery.

Materials and Methods

Study Design

This prospective randomized study was conducted in a university hospital between March 2019 and April 2020 after obtaining an approval from the local ethics committee of Necmettin Erbakan University (registration number 2019/1776). A written informed consent was obtained from each participant.

Study Population

The American Society of Anesthesiologists (ASA) status I-III patients between the ages of 65-90 years and scheduled for elective orthopedic lower extremity surgery under spinal anesthesia were included in the study. The patients with contraindications to spinal anesthesia, coagulopathy, local anesthetic allergy, infections in the intervention area, severe stenotic heart disease, and high intracranial pressure and those refusing to participate and having difficulty in cooperating were excluded.

Main Points

- Spinal anesthesia was relatively more difficult in both elderly patients and those with abnormal anatomical landmarks.
- The preprocedural USG increases the rate of successful access to subarchnoid space at the first attempt in the elderly patients with difficult anatomy.
- The preprocedural USG reduces the number of needle redirections needed to achieve successful spinal anesthesia in the elderly patients with difficult anatomy.
- The preprocedural USG did not prolong the spinal anesthesia procedure time in the elderly patients with difficult anatomy.

Before the procedure, the history and previous radiological examination findings of all the patients were meticulously evaluated. While the patients were in the sitting position, the vertebral column was physically examined, and the palpation difficulty was scored as 0, 1, 2, or 3 from easy to difficult under the classification criteria proposed by Ekinci et al. [17]. Patients with palpation difficulty score of 2 or 3 and those with anatomical abnormalities, such as scoliosis, and a history of surgery in the lumbar spine were included in the study.

General Description

Using the closed envelope method, the patients were randomly divided into the following 2 groups: group P where the landmarks were detected through conventional palpation and group U where preprocedural USG was used. The group allocation was kept hidden with sealed opaque envelopes opened by the team just before the procedure. Because of the design of the study, although it was unlikely to blind both the anesthetist performing the procedure and the patients, the researcher assessing the outcomes was blinded to group allocation. The procedures were performed by 2 anesthetists experienced in neuroaxial USG. Pulse oximetry, non-invasive arterial blood pressure, and electrocardiogram were used for routine hemodynamic monitoring of all the patients. No sedation was performed before or during the procedure.

Study Interventions

As described in detail in previous studies [20, 21], a USG device of Esaote Mylab 30 (Florence, Italy) and a 3-5 MHz convex transducer were used for systematic screening of the spine in group U. First, the probe was placed on the sacrum in the longitudinal paramedian sagittal plane, and the sacrum was defined as a hyperechoic line. The probe was then shifted toward the cranium to count the intervals of the intervertebral disks from L5-S1 to L2-L3. The midpoint of the probe was placed over the L4-L5 and L3-L4 interspinous spaces and marked on the skin by a marker pen (Figure 1).

In the second stage, the probe was placed perpendicular to the long axis of the lumbar spine in the mid-transverse plane. Interspinous processes in the midline from L4-L5 to L2-L3 and bilateral horizontally located laminae were determined by moving the probe slowly to the cranial or caudal direction. The images of the ligamentum flavum, dorsal dura complex, vertebral body, and articular processes were obtained from this range. The images of the laminae were obtained symmetrically on both sides, and the midpoint of the probe was marked. Thus, we considered preventing the failure of spinal anesthesia because of vertebral rotation in the patients with scoliosis. In USG scanning, the intersection point of the longitudinal and transverse marks was indicated as the midline of the needle insertion point (Figure 1). To obtain the clearest image of the intrathecal space, the transducer was tilted, and the angle according to the transverse plane was measured by an electronic protractor. This angle was then used as the angle for the needle pass and orientation.

In group P, spinal anesthesia was performed using the conventional landmark palpation technique and midline approach. While the patients were in seated position, a line joining the superior aspect of the iliac crests (Tuffier's line) was used to determine the vertebral level of L4. To determine the midline and lumbar intervertebral spaces, spinous processes and interspinous gaps were palpated. For the spinal anesthesia, the combination of 12.5 mg of 0.5% hyperbaric bupivacaine and 100 mcg of morphine was administered through a 25-gauge Quincke needle (88 or 120 mm).

In both the groups, strict aseptic techniques were followed throughout the procedure. A total of 3 needle insertion attempts were allowed to reach the subarachnoid space. When the initial attempt was unsuccessful, the required number of the reinsertions was recorded until the attempts were successful after the needle was completely withdrawn from the skin surface. Without withdrawing the needle completely from the skin surface, the number of trajectories required for needle redirection was recorded, and only 3 trajectories were allowed to direct the needle.

In group P, if the dural puncture failed after 3 needle insertion attempts within the same interspace or another interspace chosen, the intervention point was re-determined by USG scanning. Successful spinal anesthesia was defined as the confirmation of sensory and motor block formation at T-10 dermatomal level or 15 minutes after the procedure and successful surgical anesthesia. If the spinal anesthesia was unsuccessful after all the procedures, the patient was sedated under general anesthesia (GA). All the participants responded to a 10-point scale (ranging from 0 [no pain] to 10 [most severe pain]) to score the pain and to a 5-point scale (from 0 [very unpleasant] to 5 [very good]) to score the satisfaction. All data obtained in the study were analyzed and recorded by an independent observer.

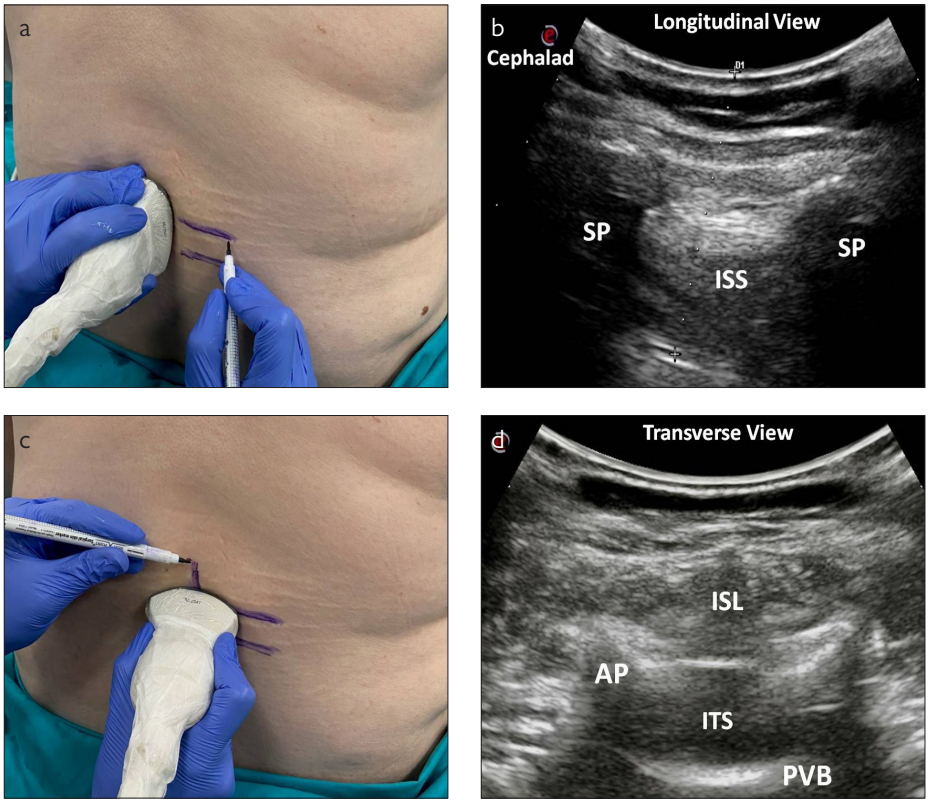

Figure 1. a-d. Preprocedural ultrasonography imaging and corresponding skin markings for spinal anesthesia (a) Skin markings at the midpoint of the probe's long edge (b) Longitudinal sonographic view of the lumbar spine (c) Skin markings at the midpoint of the probe's long and short edges (d) Mid-transverse view of the lumbar spine

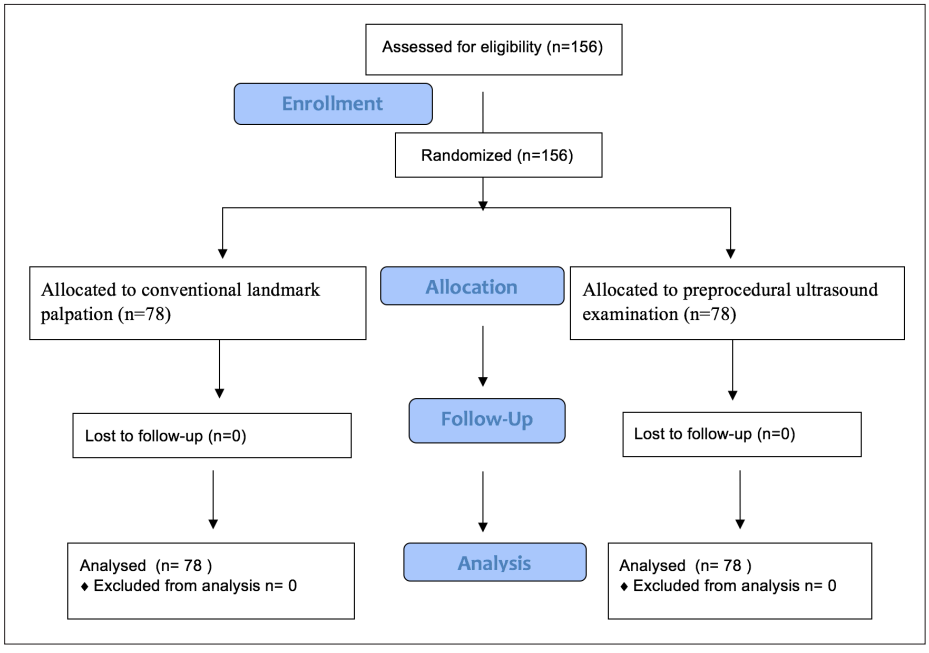

Figure 2. CONSORT (consolidated standards of reporting trials) flow diagram of patients' recruitment

Study Outcomes

The primary outcome of our study was the rate of successful access to the subarachnoid space on the initial needle insertion attempt. The secondary outcomes included the following features: the number of needle insertion attempts and needle redirections, time taken to establish landmarks, total procedure time (defined as the sum of time taken to establish the landmarks and time taken to administer spinal anesthesia), needle pain score, patient satisfaction, and the complications related to spinal anesthesia.

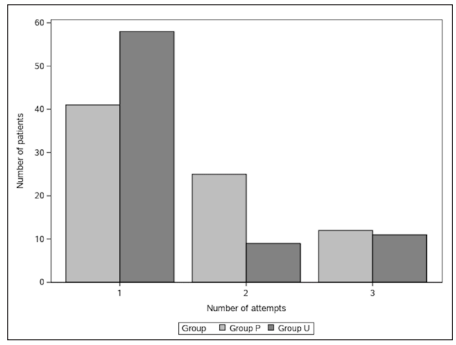

Figure 3. Number of attempts required for successful dural puncture in group P and group U

Statistical Analysis

The sample size was calculated depending on the primary endpoint (the rate of successful dural punctures at the first puncture attempt). The expected rates on the basis of a previous study that was performed with orthopedic patients were found to be 65% and 32% using the conventional landmark-guided palpation and preprocedural USG techniques, respectively [18]. We concluded that 75 patients would be required in each group (150 patients in total) to achieve a power of 0.85 and α and β errors of 0.05 and 0.15, respectively. To allow for drop-out, 78 patients were randomly placed into each group. The analyses were carried out with the Statistical Analysis Software, University Edition 9.4 program (*SAS® University Edition* 9.4; SAS Institute Inc., Cary, NC, USA). The data were given as number (proportion), mean±standard deviation, or median interquartile range (IQR [range]). The Shapiro-Wilk test was used to test continuous variables for normality, whereas continuous data were analyzed using *t* tests and Poisson regression. The categorical binary outcomes were also analyzed using the chi-squared test, and a 2-tailed p value of <0.05 was accepted as statistically significant.

Results

A total of 156 patients were enrolled and completed the study period. The consort flow diagram of the study is presented in Figure 2. No significant difference was noted between the groups P and U in terms of age, weight, height, sex, body mass index (BMI), ASA classification, and type of surgery, and the clinical characteristics of the patients are shown in Table 1. The palpation scores were 2 in 67 (85.9%) and 3 in 11 (14.1%) of the patients in group P; the scores were found as 2 in 62 (79.5%) and 3 in 16 (20.5%) of those in group U. There was no statistically significant difference between both the groups in terms of palpation difficulty (p=0.28). The patients with scoliosis and those with previous spinal surgery were equally distributed in the groups P and U. The rate of

Table 1. Distribution and comparison of demographic data and surgical characteristics

Value	Group P (n=78)	Group U (n=78)	p
Age (years)	71.74±6.50*	70.23±5.32	0.358
Weight (kg)	87.38±15.04	89.85±13.13	0.364
Height (cm)	161.92±7.88	160.63±8.17	0.061
Sex (M/F)	54 (69.2)/24 (30.8)	62 (79.5)/16 (20.5)	0.142
BMI (kg/m²)	33.05±6.04	34.3380±5.25	0.147
Previous spinal surgery	6 (7.7)	9 (11.5)	0.4
Scoliosis	22 (28.2)	19 (24.4)	0.58
Type of surgery THR/TKR/Others	10/46/22	8 /45/25	

*Data are given as number (proportion) or mean±standard deviation (SD). BMI: Body mass index, THR: Total hip replacement, TKR: Total knee replacement, M/F: male/female

Table 2. Efficacy outcomes

Value	Group P (n=78)	Group U (n=78)	p
Success rates			
Single puncture	42 (53.8)	58 (74.4)	0.008
Single redirection	18 (23.1)	28 (35.9)	0.009
Number of attempts	2 [1-3]	1 [1-2]	0.039
Number of needle redirections	3 [2-5]	2 [1-4]	0.028
Total procedure time (s)	135.8±101*	134.3±79.6	0.11

*Data are given as number (proportion), mean±standard deviation (SD) or median interquartile range [IQR (range)]

successful access to the subarachnoid space with a single intervention was significantly higher in group U (74.4%) than that in group P (53.89%) (p=0.008). The number of attempts to achieve successful dural punctures was 1 in 41 (52.6%), 2 in 25 (32.1%), and 3 in 12 (15.4%) of the patients in group P; the dural punctures were attempted in 1 in 58 (74.4%), 2 in 9 (11.5%), and 3 in 11 (14.1%) of the patients in group U (Figure 3), and the difference between the groups was detected to be statistically significant (p<0.05). In group P, the number of punctures was higher, at the rate of 28%, than that in group U (incidence rate ratio [IRR]=1.28) (1.03-1.61). In group P, the number of needle redirections was higher at 17% than that in group U (IRR=1.17) (1.01-1.35). The median (IQR; range) numbers of both needle insertion attempts (group P, 2 [1-3] vs group U, 1 [1-2]; p=0.038) and needle redirections (group P, 3 [2-5] vs group U, 2 [1-4]; p=0.028), requiring to achieve dural puncture, were significantly higher among the patients in group P than those in group U (Table 2). No statistically significant difference was found between the 2 groups in terms of the total procedure time (p>0.05).

Dural puncture could not be achieved in 4 patients in group P and 1 patient in group U despite 3 attempts. In the 4 patients with failed spinal anesthesia in group P, the re-insertion point was determined under USG guidance, and a successful dural puncture was achieved in 3 of them. However, these 3 patients were not included in group U. GA was administered in 1 patient in each group. There was no significant difference between the groups in terms of successful spinal anesthesia rates (p>0.05). In terms of pain scores because of the procedures (group P, 3 [2-4] vs group U, 3 [1-5]) or patient satisfaction scores (group P, 4 [4-5] vs group U, 3 [1-5]), there was no significant difference between the 2 groups. No spinal anesthesia-induced complications, such as paresthesia, backache, and post-dural puncture headache, developed in any of the patients.

Discussion

Our study findings showed that preprocedural neuroaxial USG improves the technical performance of spinal anesthesia in elderly patients with lumbar degeneration, difficulty in palpating landmarks, scoliosis, or previous spine surgery. We also observed that preprocedural USG imaging increased the rate of successful access to the subarachnoid space at the first attempt and reduced the number of needle redirections required for successful procedure without changing the total time compared with the landmark-guided palpation technique.

In most patients, the traditional landmark-guided technique is still the most common and effective modality used for spinal anesthesia. In the general population, for patients with easily discernible landmarks, the use of USG does not improve the technical performance of spinal anesthesia [12, 13, 22, 23]. However, USG scanning improves the spinal anesthesia procedure in those with scoliosis, history of previous spinal surgery, obesity, or difficulty in palpating the anatomical landmarks [17-19, 24]. Furthermore, it was observed that USG could facilitate the detection of the sacral hiatus and guide the injection needle into the epidural space [25]. The majority of patients who undergo lower extremity orthopedic surgery are over the age of 65 years. Spinal anesthesia can be difficult in these patients owing to the degenerative changes in the vertebral structures and difficulty in positioning. Older patients with lower BMI, no spinal deformities, and difficulty to palpate landmarks have been reported to benefit from neuroaxial USG [19, 24].

Our assumption was that spinal anesthesia was relatively more difficult in both elderly patients and those with abnormal anatomical landmarks; therefore, we investigated the effects of preprocedural USG imaging on this patient population as the number of studies in this area is limited.

In our study, the success rate of spinal anesthesia in the first attempt was 74.4% in the preprocedural group U and 53.8% in the traditional group P. In a study performed by Chin et al. [18], the use of USG in adult patients with difficult surface landmarks was reported to increase the success of the first attempt (65% vs 32%) compared with the control group. We included the patients with abnormal spinal anatomy and those with difficulty in palpation into the study regardless of BMI, and the mean age of our patients was about 10 years more than that of the patients assessed by Chin et al. [18]. In a study the efficacy of USG scanning was investigated in patients only with documented lumbar scoliosis and previous spinal surgery and Park et al. [19] showed that there was a significant increase in the success of the first attempt (50% vs 9.1%).

One of the parameters measuring the technical difficulty of neuroaxial blockade is also the number of puncture attempts required for successful procedures [18]. Multiple needle passes and manipulations are the independent predictors for the complications associated with spinal anesthesia, such as back pain, patient dissatisfaction, post-dural puncture headache, par-

esthesia, hematoma, and persistent neurologic deficit [1, 2, 26]. Our findings are consistent with those reported by several previous studies, demonstrating that preprocedural USG examination decreases the needle manipulations in the elderly [19, 24]. Our study found that the number of needle insertion attempts and the needle redirections were lower in group U.

Our findings indicated that preprocedural USG did not prolong the total procedure time. It was demonstrated in several studies that the time taken to establish the landmarks through USG scanning is longer than that for the traditional method; however, USG scanning did not affect the total procedure time in terms of reducing the time to perform spinal anesthesia [18, 19]. The time lost through USG scanning is compensated by decreasing the time spent for the procedure [2].

In this study, the dural puncture was unsuccessful in 1 (1.3%) patient in group U and 4 (5.2%) patients in group P, and thus alternative techniques were used. The conversion to GA was required for 1 patient in both the groups. In the systematic review in which Jiang et al. [23] evaluated 1844 patients, it was reported that the use of USG improved the success rate of the first pass, but there was no evidence of reduction of failed punctures. We determined no difference between the groups in terms of the complications related to spinal anesthesia. Because the serious complications of neuroaxial blockade are rare, the evidence for the reliability of USG on the same is insufficient. The use of USG in the patients with difficult palpation reduces the number of needle manipulations. In addition, the distance from the skin to the subarachnoid space can be used to determine the needle path and length, especially in obese patients [15, 16]. Therefore, a decrease in the number of spinal anesthesia-induced complications can naturally be anticipated. In a study, however, it was reported that accidental dural punctures occurred in epidural anesthesia despite the use of USG, and the risk was related to the experience of the practitioner [2]. However, another study proposed that inexperienced practitioners on receiving appropriate training for the procedure could perform successful attempts through USG in a brief time [27, 28]. Although needle manipulations were found to be decreased in our study, no difference was detected between the groups in terms of pain score and patient satisfaction related to the procedure. According to the literature, some contradictory results have been reported by previous studies. Although several studies found an increase in patient satisfaction [13, 24], others reported no significant improvement associated with the satisfaction [4, 11].

This study had some limitations. First, as the nature of the study design, both the patients and the practitioner anesthetist were not blinded. Second, the preprocedural USG technique may have shown inherent inaccurate outcomes because of saggy skin and individual difficulties of the positions among the elderly.

In conclusion, preprocedural USG increases the rate of successful access to subarachnoid space at the first attempt and reduces the number of needle redirections needed to achieve successful procedures without changing the total time in elderly patients with difficult anatomy compared with the landmark-guided palpation technique. Therefore, we believe that the preprocedural USG technique has a clinical benefit and is superior to the traditional landmark-guided technique in elderly patients and patients with difficult anatomic landmarks.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Trials Ethics Committee of Necmettin Erbakan University (1776/2019).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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Author Contributions: Concept - A.K., Y.U.; Design - A.K., Y.U.; Resources - Y.U.; Materials - Y.U., E.Y.U.; Data Collection and/or Processing - Y.U.; Analysis and/or Interpretation - A.K.; Literature Search - Y.U., A.K.; Writing Manuscript - A.K., Y.U.; Critical Review - Y.U.

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