Effect of the Height of the Operating table on Ergonomics during Spinal anesthesia

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Abstracts

Effect of the Height of the Operating table on Ergonomics during spinal anesthesia

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Introduction

The height of the operating table is related to the performance of the procedure and the discomfort of the operator. The aim of this study was to investigate the influence of different operating table heights on the accuracy of needle insertion and the discomfort of the anesthetist during spinal anesthesia.

Methods

Sixty patients were randomly allocated into 4 groups by the landmarks on the anesthetist's body: umbilicus (U), lowest rib margin (L), xiphoid process (X), and nipple (N). Before induction of anesthesia, the height of the operating table was adjusted to each group. All patients were in the lateral decubitus position with their shoulders and hips perpendicular to the table. Spinal

anesthesia was performed by median approach. The primary outcome was the 'initial angle' between the patient's skin and the spinal needle in view of coronal plane. Until the success of the spinal anesthesia, each coronal angle was measured in company with the sagittal angle. The anesthetist's posture was recorded by taking pictures and the degree of flexion of the neck, back, and knee was measured. At the end of the procedure, the overall subjective discomfort of the anesthetist was investigated.

Results

Fifteen patients per each group, exclusive of 1 case which converted to general anesthesia, were analyzed. The initial coronal angle between the patients' skin and the spinal needle was the most perpendicular in group X (90.8°) and the most remote from 90° in the group U (98.1°). The sagittal angles and the success rate were not different between the groups. The subjective necessity for bending the joints was the highest in group U. The objective degree of neck, back, and knee flexion was the highest in group U and the lowest in group X and group N. Anesthetists complained of discomfort in group U and L compared to group X and N (5.8 and 5.1 vs 2.1 and 2.3).

Conclusions

At the xiphoid and nipple level, the angle between the patients' skin and the spinal needle was optimal, and both objective and subjective discomforts of the anesthetists were minimal.

Keywords : Ergonomics, Spinal anesthesia, Height of the operating table

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Introduction

Ergonomics is the science that deals with the interaction between humans and the things people use in working environments. It considers designing equipment, devices and systems that fit the human body and behaviors, therefore help humans to work in safe and productive surroundings. Ergonomic factor during procedure and surgery is important, because physically and mentally highly skilled performance is required in medical environment [1]. It is well known that the height of the operating table can affect the performance and discomfort of the operator[2, 3], however about 11% of surgeons were aware of ergonomics guideline in Europe[4]. For anesthetists, a few reported about ergonomic consideration for anesthetists during anesthesia [5]. In a previous study, higher operating tables can provide better laryngeal view and low subjective discomfort, and thus, xiphoid process and nipple levels are preferred during laryngoscopic intubation, and mask ventilation [6].

Spinal anesthesia is one of the most common procedures to anesthetists, but to our knowledge, there are no studies or suggestions about adjusting the height of the operating table in spinal anesthesia. In median approach of spinal anesthesia, anesthetists are recommended to insert the needle perpendicular to the patient's back, horizontal to the floor[7]. As this angle is closer to 90 degrees, it is regarded as an index for better performance. Inconvenient and clumsy performance at an inappropriate operating table height results in the operator's physical fatigue, an

unintended direction of needle entry, low success rate and increased complication due to repeated trials.

The purpose of this study was to analyze the accuracy of needle insertion and the discomfort during different ergonomic conditions faced by anesthetists during spinal anesthesia. In particular, authors intended to compare the angles between the patients' back and the inserted spinal needle in the coronal plane at different operating table heights. Furthermore, we report sagittal angle of the spinal needle and objective and subjective flexion of the joints during the procedure.

Methods

This prospective randomized clinical study protocol was reviewed and approved by the Institutional Review Board of Seoul National University Bundang Hospital (IRB no. I-2014-6010).

Sixty patients were recruited undergoing elective surgery under spinal anesthesia and all patients provided written informed consent prior to study enrollment.. The exclusion criteria were contraindications for spinal anesthesia, age<18 or >75yrs, body mass index (BMI)>30, and history of spine operation or severe anatomical abnormalities of spine. The patients were randomly allocated to one of four groups: Group U, L, X, and N. These acronyms indicate the heights of the operating table which set at the needle insertion point of anesthetists, namely the level of umbilicus, lowest rib margin, xiphoid process, and nipple in a standing posture. These body landmarks were selected because they are easily checkable and are within the boundary of height that commonly performed at [6]. There were no selection criteria for anesthetists who performed spinal anesthesia except for those markedly obese or pregnant.

All patients were firstly in supine position for routine monitoring, checking of oxygen saturation, electrocardiography, and noninvasive blood pressure, and then turned to lateral decubitus position. Patients were placed with the back parallel to the edge of the operating table nearest to the anesthetists, with knees flexed upon the abdomen, and the neck flexed to allow the forehead to be as close as possible to

the knees. To ensure that the patients' plane of back remains perpendicular to the operating table, the assistant checked that the angle between the table and the patients' shoulder or hip was maintained at 90 degrees by using a protractor. One examiner was not blinded to study group assignment, and he adjusted the height of the operating table according to 1 of 4 study groups which was assigned by the random table. Both the anesthetist and the assistant who took pictures were blinded to the subjects' group assignments and not specifically told that it was an active intervention about the procedure throughout the duration of the study.

After sterilizing the field by chlorhexidine and waiting until it has dried, local anesthetics was injected at the level of the chosen space. Next, the 25 gauge Quincke spinal needle was introduced in the midline, within the range of directing 10-15 degree cephalad. As the needle entered deeper, it would meet the point whether loss of resistance or bone contact. Either way, at that point, the angle between the patient's skin and the spinal needle was measured as 'initial angle' by the protractor in the coronal and sagittal plane. If freely flowing of CSF was not seen in all directions, the needle was redirected in the coronal plane and the angles were recorded for each trial. If spinal anesthesia was not succeeded within five times, it was dropped out from this study and changed either the table height, paremedian approach, or the anesthetist.

During the procedure, the assistant took pictures of the anesthetist who performed spinal needle insertion at the edge of the table, covering the anesthetist's head to toe. The degrees of neck, lower back, and knee flexion were measured by the other

blinded investigator with a protractor through these pictures. The reference point of flexion angle was set to an imaginary line perpendicular to the floor. Also, the angle of view was measured, which was formed between two imaginary lines, one started from the anesthetists' eyes and ended at the spinal needle insertion point, and the other started from the needle insertion point and went horizontally to the table. After completing the procedure, the anesthetists were asked to record the subjective general discomfort graded by Numeric Rating Scale (0 to 10, 0= very comfortable, 10= severe discomfort) and whether they bended the joints heavily or not.

A pilot study (10 patients for each Groups U and N) had been conducted for estimating the sample size. When a difference of 6° in the coronal angle was accepted, 13 patients per group were required to achieve two-tailed, alpha 0.05, and 80% power. Assuming a dropout rate of 10%, a total of 60 patients would be needed to detect a significant difference.

For the purpose of comparisons, continuous numerical data were summarized with descriptive statistics and analyzed with the use of the analysis of variance (age, BMI, angles of needle and joint flexion). Categorical variables were compared by means of exact chi-square test (sex, subjective assessment of joint flexion) and Kruskal-Wallis test (ASA classification). P-values less than 0.05 were considered as statistically significant. Scheffe post hoc analysis was used for between-group comparisons. SPSS version 19.0 was used for performing statistical analyses.

Results

Sixty patients were recruited, and 1patient was excluded form involvement in our study due to failed spinal anesthesia after the 5th trial of median approach. There was no complication recorded during spinal anesthesia and in-hospital period postoperatively. Seven anesthetists with a 4.0 (±1.5) years of experience, height of 162.5 (±1.8), and no musculoskeletal disorders were involved. Demographic data of patients and anesthetists are shown in Table 1 and Table 2.

The angles between the patients' back skin and the spinal needles in the coronal plane were obtuse in Group U, nearly perpendicular in Group X, and slightly acute in Group N. The results revealed a similar trend both in the initial and the success trials. The angles in the sagittal plane and the number of advances were not statistically different between four groups (Table 3).

Anesthetists' discomfort scores were higher in the lower level of the operating table (Group U and L) than in the higher level (Group X and N) ($p<0.001$, Table 4). The frequency of neck, lower back, and knee flexion was higher in the lower level of the operating table. The degrees of flexion of all joints were greater in Groups U and L than in Groups X and N ($p<0.001$). Furthermore, the angles of view were shown in similar trends with the degrees of joint flexion, much greater in Group U and L than in Group X and N ($p<0.001$).

Table 1. Patient characteristics.

	U (n=15)	L (n=14)	X (n=15)	N (n=15)
Age (yr)	51.5 ±19.2	43.6 ±20.3	48.1 ±16.0	49.56 ±17.8
Sex (M/F)	9/6	10/4	9/6	8/7
ASA (Ⅰ/Ⅱ/Ⅲ)	8/6/1	7/9/0	7/7/1	9/6/0
BMI (kg/m2)	24.6 ±5.2	24.0 ±3.5	23.6 ±2.1	24.5 ±3.7
Compliance on positioning (0/1/2/3)	0/0/5/10	0/0/3/11	0/2/3/10	0/0/2/13

Values are expressed as mean ± SD or number of patients.

Group U (umbilicus); Group L (lowest rib margin); Group X (xiphoid); Group N (nipple).

ASA, American Society of Anesthesiologists physical status classification system;

BMI, Body mass index.

Table 2. Anesthetists' demographics.

	U (n=15)	L (n=14)	X (n=15)	N (n=15)
Height (cm)	162.5 ±1.8	162.5 ±1.3	163.2 ±1.5	162.4 ±1.4
Experience in anesthesia (year)	4.1 ±2.7	2.9 ±1.3	4.4 ±3.4	4.0 ±1.7

Values are expressed as mean ± SD.

Group U (umbilicus); Group L (lowest rib margin); Group X (xiphoid); Group N (nipple).

Table3. Angles between patients' back and spinal needles. Numbers of trials.

	U (n=15)	L (n=14)	X (n=15)	N (n=15)	p value
Coronal angle (initial)	98.1 ±9.2	92.2 ±6.5	90.8 ±6.5 *	88.7 ±4.7 *	0.003
(on success)	99.2 ±9.3	94.4 ±6.1	90.0 ±5.7 *	89.4 ±3.2 *	<0.001
Sagittal angle (initial)	93.5 ±9.7	96.9 ±5.2	99.9 ±4.6	100.0 ±5.4	0.091
(on success)	97.3 ±5.6	97.4 ±5.4	99.2 ±3.8	100.5 ±9.7	0.646
No. of trials	1.5 ±0.6	1.6 ±0.6	1.3 ±0.5	1.5 ±0.5	0.479

Values are expressed as mean ± SD.

* :p<0.05 vs group U

Group U (umbilicus); Group L (lowest rib margin); Group X (xiphoid); Group N (nipple).

Table 4. Anesthetists' subjective assessments, objective angles of joint flexion, and angles of view.

	U (n=15)	L (n=14)	X (n=15)	N (n=15)	p value
Discomfort(NRS)	5.8 ±2.0	5.1 ±1.3	2.1 ±1.6 * †	2.3 ±1.3 * †	<0.001
Neck flexion	15	14	13	2	<0.001
angle	64.7 ±11.1	65.4 ±8.7	48.6 ±11.7 * †	38.3 ±8.4 * †	<0.001
Back flexion	12	13	1	0	<0.001
angle	25.7 ±13.3	12.1 ±9.6 *	1.8 ±5.4 * †	0.0 ±0.0 * †	<0.001
Knee flexion	9	2	0	0	<0.001
angle	15.3 ±7.7	5.7 ±6.5 *	1.4 ±3.6 *	0.0 ±0.0 *	<0.001
Angle of view	67.6 ±3.2	65.7 ±3.6	56.2 ±4.4 * †	51.0 ±3.5 * †	<0.001

Values are expressed as mean ± SD or number of patients.

* :p<0.05 vs group U, †: p<0.05 vs group L

Group U (umbilicus); Group L (lowest rib margin); Group X (xiphoid); Group N (nipple)

Discussion

This study demonstrated that the anesthetists could approach spinal needles at better insertion angles and feel more comfortable on higher operating tables (at the xiphoid process and nipple level of the anesthetists) during spinal anesthesia. However, the success rate and the number of attempts were not significantly different among the four groups. These results could be explained by self-adjustment using bad postures in suboptimal environments. Therefore, anesthetists' discomfort needs attention despite the similar outcomes in spinal anesthesia practice.

Ergonomics has recently emerged as an important subject for healthcare providers. Not only patients, but also operators can suffer from bad occupational environments. Musculoskeletal disorders in surgical teams have been faced as a significant occupational hazard and they are increasing markedly owing to advances in surgical technology [8]. There are only a few studies dealing with ergonomic concerns in anesthesia, and none of them investigated about the interaction between factors such as environment, patient, and operator in spinal anesthesia. Muhammad et al analyzed the performance of spinal anesthesia in an orthopedic operating room of acute hospital setting, applying ergonomic task analysis, and revealed about the current suboptimal environments in spinal anesthesia; for example, strained body muscles, extremely rotated spines of anesthetists, inappropriately arranged objects for spinal anesthesia, inconsistency of surroundings, and so on[9]. Among them, we particularly focused on the performance and the anesthetists' discomfort depending

on different heights of the operating table. Furthermore, spinal needle has to be controlled in a delicate manner to insert through narrow interspinous spaces. Considering the anatomy of lumbar spines, the angle of spinal needle insertion is suggested as the following; perpendicular to the skin, horizontal to the floor, 10 to 15 degrees cephalad in median approach[7, 10].

In general, optimal working heights for standing workers are recommended within a range from 5 cm above to 10 cm below the elbow[11]. According to this opinion, our study Group U, L and X were within this ideal elbow height range, except Group N. However, for spinal anesthesia, the ideal viewing height should be considered together, because a spinal needle does not draw a line parallel to anesthetist's line of sight. Spinal anesthesia is qualitatively different from other surgeries performed on the operating table where main gaze is vertical down to the surgical fields. Eyes are looking down at the needles from both side, and hands are manipulating the needle with misaligned eyes. The obtuse angles of coronal plane in Group U and L can be interpreted as compensatory behavior for a low height to eyes level. In Group X and N, the more horizontal line from the anesthetist's eyes could be formed and could accommodate comfortable viewing. In this regard, authors suggest Group X and N as an ideal height for spinal anesthesia.

Anesthetists' subjective discomfort scores were lower in Groups X and N mainly due to less joint flexion than in Groups U and L. The subjective reports of flexion of the joints were greater in lower table heights, almost always in Group U. Those evaluations of inevitable bending of the joints imply complaints to the ergonomics

during the procedure. Musculoskeletal discomfort of the neck, back and knees can lead to fatigue and distorted angle somewhere in the body and chronic pain.

The angles of view also demonstrated that Group X and N provide better environment for spinal anesthesia than Group U and L. Even though anesthetists had a tendency to flexing more their joints in Group U and L, the angles of view in those groups were farther from horizontal sight to the insertion points than in Group X and N. As a result, in Group U and L, not fully compensated angles of view by postures made the insertion angles in coronal plane deviated from perpendicular, not to mention anesthetists' physical discomfort.

There are some limitations to this study. First, single-blind experimental design was used. We made the assistant adjust the table height according to randomization, but the experimenters could assume which study group they were involved in. But the experimenters were not informed of the purpose and details of the study, it was expected to have little bias on the results. Second, in measuring the discomfort of the anesthetists, we did not employ more objective assessment of discomfort, i.e. physical workloads measured by electromyography or skin conductance[2]. Finally, we did not consider conducting the procedure in sitting posture which is also very common in clinical setting.

In conclusion, the operating tables which are at the xiphoid and nipple level of the anesthetist can provide better insertion angles of the spinal needle, with less discomfort during spinal anesthesia. This study can be used as a guide to improve the performance and the workspace environment during spinal anesthesia.

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국문초록

서론

수술대의 높이가 외과의 및 마취의의 수행 능력 및 신체적 피로도와 관련이 있다는 것은 이미 알려져 있다. 본 연구에서는 천자 바늘이 환자 피부의 관상면에 가장 수직으로 삽입되면서 시술자가 편안함을 느끼는 적절한 수술대의 높이를 조사해보고자 한다.

방법

환자는 천자 바늘이 환자의 피부를 뚫는 점의 높이가 시술자의 신체 부위 중 배꼽, 늑골의 가장 아래 경계선, 검상돌기, 유두에 해당하는 높이로 수술대를 위치시키기로 정의한 네 군으로 무작위 배정하였다. 환자는 척추 마취를 위하여 옆으로 누운 자세에서 어깨와 둔부를 침대에 수직이 되게 자세를 취하였다. 주 종속변수는 천자바늘이 관상면 상에서 환자 피부와 이루는 각도로 하였다. 척추 마취는 정중 접근법으로 시행하였고 성공하지 못하였을 경우 5회까지 시도하면서 매번 각도를 측정하였다. 시술자의 측면 사진을 촬영하여 시술자가 목, 허리, 무릎, 팔의 굽힘 정도를 측정하였고, 시술자의 주관적 불편감을 조사하였다.

결과

각 군당 열다섯 명의 환자들을 분석하였다. 환자 피부와 천자 바늘이 이루는 각도는 검상돌기와 유두 군에서 수직에 가까웠고, 배꼽 군에서 가장 수직에서 멀었다. 목, 허리, 무릎의 객관적인 굽힘 정도와 주관적인 불편

감은 배꼽 군에서 가장 높았고 검상돌기 군에서 가장 낮았다. 척추 마취의 성공률은 군들간에 차이를 보이지 않았다.

결론

척추 마취의 천자점이 시술자의 검상돌기, 유두에 위치시키는 수술대의 높이에서 바늘의 삽입 각도가 가장 이상적이었고 시술자의 객관적, 주관적 불편감이 적었다.

주요어 : 인체공학, 척추마취, 수술대의 높이

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