INTRODUCTION

Neuraxial blockade, a commonly performed, landmark-based anaesthetic or analgesic technique, can be difficult in certain patients for as yet unclear reasons. Technical challenges in the performance of this blind technique warranted an investigation into the reasons for difficulty in its performance. The quality of anatomical landmarks has been traditionally considered the single most important predictor of technical difficulty for neuraxial access. Several studies have devised grading and scoring systems to classify the quality of landmarks. Anatomic landmarks have so far been subjectively graded by different studies as either none (if the spinous processes were non-palpable), poor (if hardly palpable) and good (if easily palpable) or Grade 1 (spinous processes are visible), Grade 2 (spinous processes are not seen but easily palpated), Grade 3 (spinous processes are not seen but barely palpable under the thumb) and Grade 4 (none of the previous). While significant differences were found between easily palpable or Grade 1 anatomy, and the ease of a spinal, no differences were found between hardly palpable and poorly palpable or Grades 2, 3 and 4 anatomy, introducing the difficulty of clinically applying these results.

The percutaneous window to access the interlaminar space is defined by the bony confines of the spinous process and the lamina. Our study was designed with the specific aim of using the spinous process dimensions (the spinous process width (SPW) and the interspinous gap (ISG)) to predict ease of access to the neuraxial space. Methods: Two hundred and two consecutive patients scheduled to have spinal anaesthesia for various surgical procedures were enrolled prospectively after institutional approval. Following proper positioning for the neuraxial blockade, the ISG and SPW at the intended level were measured with calipers. The number of attempts, and redirections at the selected spinal level, and the number of levels required for successful needle placement were also recorded. Results: Group-wise analysis of the data into patients requiring >1 attempt, >1 level and ≥3 redirections showed that the single independent predictor of a difficult neuraxial block was the ISG. Twenty-three percent of the patients required more than one attempt, with a mean gap of 6.35 (±1.2) mm, in contrast to 8.15 (±2.4) mm in those with a single attempt (P=0.000). In addition, 16% of the patients needed more than one level, with a mean gap of 6.03 (±2.01) mm in contrast to 8.07 (±2.37) mm for a single level (P=0.000). Conclusions: The single independent predictor of ease or difficulty during spinal anaesthesia was the ISG (P=0.000).

Key words: Difficulty, spinal anaesthesia, spinous process
Shankar, et al.: Spinous process and spinal anaesthesia

At a selected level. Assessment of the vertical length of the spinous process does not aid neuraxial needle placement. Hence, we hypothesised that the ISG and the SPW are likely predictors of ease or difficulty in accessing the neuraxial space. Spinal anaesthesia was selected in this preliminary study as a better modality for assessing technical success as there is a clear end point with intrathecal access (free flow of cerebrospinal fluid) as compared with epidural, where the possibility that the loss of resistance used in epidural needle placement may, erroneously, occur at locations other than entry to the epidural space.

METHODS

After obtaining institutional approvals, consecutive patients scheduled for surgery under spinal anaesthesia were prospectively enrolled from a population in Tamilnadu, India belonging to the same ethnicity. Inclusion criteria were patients scheduled for surgery under spinal anaesthesia, ability to provide informed consent, no evidence of infection or on anticoagulants. Patients not able to provide informed consent, on anticoagulants, having an ongoing infection, either locally or bacteraemic, were excluded. The study was concluded at approximately 12 months as the anaesthesiologist moved from the location. Informed consent was obtained from all subjects. Demographic data including age, gender, height and weight were recorded prior to performing the spinal anaesthetic. The patient was held by an assistant until the spinal was completed after actively flexing the spine in the lateral decubitus position to the maximum extent possible by drawing the knees to the chest and flexing the neck [Figure 1]. This limited any positional changes, from measurement to needle placement. It was ensured that the pelvis and shoulder were level with the operating table. If necessary, additional wedges were provided so that the spine was relatively straight. The spinous processes above and below the level determined by the anaesthesiologist for accessing the intrathecal space was then palpated and the edges marked on the skin with a thin skin marker [Figure 2]. The ISG between adjacent spinous processes and the SPW at these locations were measured with a caliper from the surface markings. As there was no appreciable difference in SPWs above and below the levels, only one of them was included for all analysis. Patients were classified as having “difficult spinal anatomy” if they had any palpable spinal deformity, e.g. lordosis, kyphosis, scoliosis or prior back surgery. The levels were estimated based on Tuffier’s line corresponding to the L4–L5 level.

An attempt was defined as every withdrawal of the needle either out of the skin or to less than approximately 1 cm from the skin prior to advancing again. All new skin punctures were considered an attempt, whether at the initial spinal level or at a second level. Withdrawal of the needle beyond approximately 1 cm from the skin to change the direction of approach was regarded as a redirection. This was based on an earlier study looking at predictors for neuraxial access.[3] The number of redirections, attempts and requirement of another level were recorded.

Three outcome measures were used to assess the difficulty encountered in performing the spinal, namely ≥3 redirections, >1 attempt and >1 level, although these cut-offs were chosen based on an earlier study, where

**Figure 1:** Photograph showing how the patient was positioned and held by an assistant prior to the measurement and until completion of the spinal anaesthetic administration

**Figure 2:** Photograph showing the interspinous gap marked with a skin marker after patient positioning
increasing number of attempts and more than one level were considered difficult neuraxial placement. Finally, the success or need for additional anaesthesia was also recorded. Data collection and anaesthetic management was performed by an experienced anaesthesiologist (HS) with over a decade of clinical experience at the time of data collection. The responsible anaesthesiologist also determined the level/s of access, the needle type and gauge, depending on availability.

SPSS for Windows version 17 (IBM SPSS Inc., Chicago, IL, USA) was used for statistical analysis. 1-Sample Kolmogorov Smirnov Z test and visual assessment of distribution curves was conducted to assess deviation from Gaussian distribution and guide application of parametric (t-test) versus non-parametric (Mann-Whitney U test) tests to compare the two groups. For descriptive purposes, normally distributed variables were expressed as mean ±1 SD and non-Gaussian data as median (inter-quartile range). P-value <0.05 was considered significant. Logistic regression was used to identify significant independent predictors for the three outcomes. Spearman’s correlation was used to evaluate correlations between non-parametric data. Pearson’s Chi square test was used to evaluate whether distributions of categorical variables differed from one another.

**RESULTS**

Two hundred and one subjects were prospectively enrolled in the study. The male to female ratio was 61:39. The median age of the study population was 30 (24–48.5) years and the mean weight was 59 ± 12.5 kg. All neuraxial blocks were performed using a midline approach with the subject in the lateral decubitus position, except in six subjects where a sitting position was used. During the placement in the sitting position, the patient was held by an assistant and similar measurements were obtained. The L3-L4 spinal level, based on the intercristal line, was accessed in 69% of the subjects and the L4-L5 level in 21% of the subjects for the first attempt. Depending on availability, a 26 G (74% patients) or a 25 G (16% of patients) Quincke spinal needle was used. An introducer was used in 13 patients based on perceived difficulty in needle placement by the anaesthesiologist. Free flowing cerebrospinal fluid was obtained in all subjects before the injection of local anaesthetic. All spinal anaesthetics were successful. 28.3% of the patients required ≥3 redirections, 22.8% required >1 attempt and 15.9% required >1 level.

Patient characteristics are listed in Table 1. Patient features (continuous variables) associated with ≥3 redirections, >1 attempt and >1 level are listed in Table 2. Weight, ISG and difficult spinal anatomy were individually predictive of difficulty, as assessed by the three outcome variables, while age and SPW were not.

Using logistic regression analysis of the three outcome variables with the three independent predictive variables (weight, ISG, difficult spinal anatomy), ISG alone significantly predicted all three outcomes [Table 3]. In other words, with increasing ISG, there were increased 1st attempt and 1st level successes and fewer redirections, as shown by the odds ratio [Table 4]. There was a decreasing trend of difficulty with increase in the ISG [Figure 3].

There was no statistically significant difference in the ISG or SPW between subjects <60 and ≥60 years of age (P=0.99 and 0.25, respectively).

**DISCUSSION**

Our study, with a specific focus on the spinous processes, being an offshoot from prior studies that had suggested landmarks as predictors of difficult neuraxial blockade may be clinically more applicable.[1,2] Proper patient positioning is important
for the success of neuraxial blockade, and is impeded by pregnancy, spinal deformities and advanced age. [4]

The majority of our patients had the procedure performed in the lateral decubitus position. Decision to use the sitting position was made at random and on a trial basis by the anaesthesiologist. According to de Oliveira Filho et al., anthropometric impediments to proper patient positioning are age >65 years, body mass index (BMI) >30 kg/m², abnormal spinal anatomy and short, broad biotype (brevilineal, based on the xipho-costal angle >90°). Their report also highlighted that anatomical landmarks are poor with age >40 years, BMI >25 kg/m², abnormal spinal anatomy and those with brevilineal biotype. [3] The depth to the neuraxial space and BMI was shown to be a predictor of success, along with the practitioner’s experience in a more recent study. [6] Our analysis did not find body weight or height to predict a successful outcome when ISG and spinal difficulty were held constant. BMI could not be calculated in all our subjects due to missing height data in 119 subjects. Our study also did not find a significant difference in the ISG between patients younger and older than ≥60 years of age. Chien et al. reported that age and gender were not associated with the first-level success or first attempt success, which was similar to our study. [2]

Contrary to our hypothesis, SPW was not found to be a predictor of ease or difficulty. Further, the SPW had no correlation with ISG (P=0.49). Surprisingly, the use of an introducer increased the number of attempts and levels. Our data does not allow interpretation of this finding to determine a subjective assessment of difficulty felt by the anaesthesiologist. Prior studies have reported that neither needle type nor gauge affects the difficulty of subarachnoid blocks, and our data does not permit a comparison of the different gauges used. [2,7,8]

Not surprisingly, difficult spinal anatomy was associated with requirement of ≥3 redirections, >1 attempt and >1 level. Difficult spinal anatomy as a description included patients with visible or palpable deformity as well as prior spine surgery. Body habitus and spinal anatomy have been shown to be predictors of success. [2,5] Our results are in contrast to an earlier report in which first-level success was not affected by spinal anatomy, age, sex or body habitus for either spinal or epidural blocks. [3]

There are a few limitations to our study, including the overall low body weight of the study population. This may also be the reason for the absence of Grade 4 anatomic landmarks in our subjects, although prior studies had shown poor correlation between landmarks and BMI. [3] As this was a preliminary study, no power analysis was conducted prior to the study. The translation of palpatory observations of the spinous process dimensions for the determination of exact dimensions may pose a challenge. Skin turgor and

| Table 2: Predictors of a difficult spinal based on three outcome variables (≥3 redirections, >1 attempt and >1 level) |
|---|---|---|---|---|---|---|---|---|
| ≥3 redirections | <3 redirections | P-value | >1 attempt | 1 attempt | P-value | >1 level | 1 level | P-value |
| Age* (years) | 28 (24–50) | 30 (24–47) | 0.995 | 30 (23–52.25) | 29 (24–48.5) | 0.47 | 36.5 (23.25–52.25) | 29 (24–46.5) | 0.38 |
| Weight (kg) | 63.43 (±12.74) | 57.23 | 0.002 | 63.98 (±11.3) | 57.49 (±12.5) | 0.002 | 65.19 (±10.35) | 77.8 (±12.58) | 0.002 |
| ISG* (mm) | 6 (5–8) | 8 (7–10) | 0.000 | 6 (5–8) | 8 (6–10) | 0.000 | 5 (5–8) | 8 (6–10) | 0.000 |
| SPW* (mm) | 9 (8–11) | 10 (8–11) | 0.912 | 10 (8.75–11) | 10 (8–11) | 0.87 | 10 (8.25–11) | 10 (8–11) | 0.83 |

Mann-Whitney U test. Median values with interquartile range in parentheses; ISG - Interspinous gap; SPW - Spinous process width

| Table 3: Logistic regression model for predicting difficulty of spinal as defined by the three outcome variables using three independent predictive variables |
|---|---|---|---|
| B | Std. error | P value |
| ≥3 redirections | Weight (kg) | 0.026 | 0.015 | 0.811 | 1.025 |
| Anatomic difficulty | -1.148 | 0.611 | 0.060 | 0.317 |
| ISG (mm) | -0.328 | 0.082 | 0.000 | 0.719 |
| >1 attempt | Weight (kg) | 0.029 | 0.016 | 0.064 | 1.029 |
| Anatomic difficulty | -0.801 | 0.595 | 0.178 | 0.448 |
| ISG (mm) | -0.327 | 0.087 | 0.000 | 0.721 |
| >1 level | Weight (kg) | 0.033 | 0.018 | 0.067 | 1.034 |
| Anatomic difficulty | -0.989 | 0.617 | 0.109 | 0.372 |
| ISG (mm) | -0.375 | 0.105 | 0.000 | 0.688 |

B = coefficient for the constant; Exp. (B) = exponentiation of the B coefficient (odds ratio); ISG - Interspinous gap

| Table 4: Odds ratios from logistic regression model for predicting ease of spinal in relation to ISG in mm |
|---|---|---|---|
| Odds ratio | Confidence interval | P value |
| <3 redirections | 1.39 | 1.183–1.629 | 0.000 |
| 1st attempt success | 1.39 | 1.17–1.645 | 0.000 |
| 1st level success | 1.45 | 1.185–1.786 | 0.000 |

ISG - Interspinous gap
movements could potentially alter these dimensions and affect the precision of the final measurements. To decrease its impact, the patient was held in place by an assistant until the spinal anaesthetic was completed and to limit aberrancies in data collection. One could argue that the measurement of ISG with skin markings and calipers may be subjective, preventing an objective assessment of fine differences. Our results demonstrate an obvious trend of increasing difficulty in spinal needle placement with decrease in ISG. The final limitation is the performance of the spinal anaesthetic by the investigator collecting the data and measurements introducing an observer bias. Although prior knowledge of the spinous process dimensions can introduce a bias during the subsequent performance of the spinal anaesthetic, our data shows that few patients with larger interspinous gaps also required more than one attempt, suggesting that this bias was minimal.

CONCLUSION

In conclusion, the SPW measured by palpation does not correlate with ease or difficulty of spinal needle placement. The ISG best predicts difficulty of a spinal needle placement in this patient population. Future studies may consider including imaging confirmation of the palpated measurements for further validation.

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