Usefulness of a visual aid in achieving optimal positioning for spinal anesthesia: a randomized trial

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Abstract

Background: Optimal patient positioning is perceived as an essential factor to increase the success of performing neuraxial block. The primary objective of this study was to evaluate the benefit of using a visual image in addition to verbal instructions in order to optimize positioning for spinal block.

Methods: This was a prospective randomized controlled trial on 85 adult patients undergoing lower limb joint replacements at a tertiary academic hospital. Group 1 (n = 43) randomized to receive standardized verbal instructions; Group 2 (n = 42) received standardized verbal instructions in conjunction with visual aids to achieve positioning for spinal anesthesia. The primary outcome measure was the time taken to successful dural puncture. Secondary endpoints were the number of skin punctures, number of intervertebral levels attempted, success at the first intervertebral space attempted and satisfaction of patients and anesthesiologists.

Results: The unadjusted geometric mean time taken for the procedure using verbal instruction alone was 301 s (95% CI: 236–385) compared to 183 s (95% CI: 143–235) when both verbal and visual instructions were used. Out of the participants in group 2, 90% required ≤2 skin punctures and 10% required ≥3 skin punctures compared to 65% and 35% of the participants in group 1 respectively (p = 0.001). Group 1 required a second anesthesiologist to successfully complete the procedure in 6 patients out of 43 (14%) patients whereas the first anesthesiologist was noted to be successful in all the 42 cases in group 2 (p = 0.03). There were no significant differences in the satisfaction scores of anesthesiologists or patients between the groups. First-pass success was strongly associated with patient satisfaction (Odds ratio: 5.2; 95% CI: 1.0–9.5, p = 0.049).

Conclusions: Use of a visual aid in addition to verbal instructions to optimize positioning for a spinal block, significantly reduces the time taken for the procedure by an average of 2 min, reduces the number of skin punctures and increases the success rate of the first anesthesiologist. First pass success was strongly associated with patient satisfaction.

Trial registration: This study was retrospectively registered 30 August 2016, with the Australian New Zealand Clinical trials registry (ACTRN12616001197426).

Keywords: Anesthesia, Patient positioning, Anesthesia, Spinal
Background
Anesthesiologists traditionally perform neuraxial block utilising landmark-based techniques and the most significant predictor of the difficulty in performing them has been reported to be the quality of these landmarks [1]. Besides landmark quality, patient positioning can also independently predict the success of performing neuraxial anesthesia [2].

Patients are often verbally instructed by the anesthesiologist to adopt an optimal position for neuraxial blocks. Difficulty can be encountered in achieving the best position if patients misunderstand these instructions. This may lead to a delay in performing the procedure and increase the technical difficulty with a possible increased risk of complications [2]. Further, it may result in the anesthesiologist abandoning the procedure despite the possible advantage of neuraxial anesthesia for the patient. Multiple punctures can lower patient satisfaction and may lead to complications such as hematoma, paresthesia and nerve injury as well as post dural puncture headache [1, 3, 4].

Although there have been many studies discussing the predictors for a difficult neuraxial blockade [1, 2, 5], few studies have looked at techniques to minimise these difficulties. Ultrasound has been investigated; however, this technique requires specific training and expertise. One previous study demonstrated that use of visual aids resulted in better positioning in obstetric patients undergoing epidural anesthesia [6]. However, the potential benefits of employing a simple visual aid amongst a more general surgical population remain unexplored.

The aim of our randomized controlled study was to assess the effects of showing patients visual images of the optimal position, in addition to providing verbal instructions, for the placement of spinal anesthesia when compared to providing standardized verbal instructions alone, in adult patients undergoing hip and knee arthroplasty. We hypothesized that the addition of the visual aid would result in improved positioning resulting in reduced time taken for the procedure, improved ease of placement measured by the number of skin punctures required and higher patient satisfaction.

Methods
The study was approved by the Institutional Human Research and Ethics Committee on the 20th December 2013 (HREC/13/QPCH/335). It was retrospectively registered with the Australian New Zealand Clinical trials registry (ACTRN12616001197426). Adult patients undergoing elective hip and knee arthroplasty under spinal anesthesia were included in this prospective randomized controlled study conducted at the Prince Charles Hospital, Brisbane, Australia. Exclusion criteria were refusal to consent, inability to read or comprehend English, any contraindication to neuraxial anesthesia, prior experience with neuraxial blocks, body mass index (BMI) greater than 45 kg/m² and anticipated positioning difficulties due to severe arthritis or major spinal deformities.

Following written informed consent, the eligible participants were randomly allocated into two equal groups, based on computer generated random numbers. Random allocation was achieved by means of double opaque, sealed envelopes marked with trial identification numbers. Blinding was not possible due to the nature of the intervention. Participants in group 1 received standardized verbal instructions only, whereas those in group 2 were additionally shown visual images of the preferred position. The standardized verbal instructions used for all the participants are given in detail (see Additional file 1). These included commonly used phrases, agreed upon after discussion with anesthetic colleagues. The visual images used in this study for the participants in group 2 included photos of one correct position and three incorrect positions. The images intended to convey the same information as the verbal instructions. These images are provided in detail (see Additional file 2).

Following intravenous cannulation and application of standard monitoring, the participants were requested to sit in the upright position on the operating table with their feet resting on a stool, and shoulders gently supported by an assistant. No further assistance in positioning or any verbal prompting was provided by the theatre assistant. No sedative or anxiolytic premedication was administered to the participants, due to possible interference with their comprehension. Anesthesiologists were allowed to choose the type, level, and approach of the block, as well as the needle and local anesthetic used.

The anesthesiologist prepared the spinal tray and drugs under aseptic conditions, and prepared and draped the patient’s back. A second person started the timer and read out the standardized verbal instructions with or without visual aids, according to the allocation group of the patient. The patient then adopted the required position, and the anesthesiologist immediately commenced the procedure. A trained independent observer recorded the relevant data.

The primary outcome measured was the length of time taken until successful needle placement. This was defined as the time in seconds from the start of the instructions until the free flow of cerebrospinal fluid (CSF). Secondary endpoints included number of skin punctures, number of intervertebral spaces that were attempted, success at the first attempt (first pass success), number of anesthesiologists required to successfully complete the procedure and satisfaction scores for both the anesthesiologist and the patient. The number of skin punctures was the total count of all the skin punctures excluding local anesthetic infiltration [7]. The number of intervertebral spaces was the number of spinal levels attempted. Satisfaction scores were assessed on a numerical scale of 1–5 (1: very unsatisfied and 5: very satisfied).
A sample size of approximately 43 patients per group was calculated, based on obtaining 90% power to detect a difference of 2.5 min between average times for the two interventional groups, at a 5% significance level and based on a standard deviation of approximately 3.5 min [8].

The distribution of the primary outcome of interest, time to successful needle placement, was positively skewed so a natural logarithmic transformation was applied to derive a normally distributed outcome variable (log-time) for use in statistical analyses. The exposure of interest was the instruction group (verbal only versus verbal plus visual). Potential confounders of interest included age, sex, BMI, educational level, experience of the first anesthesiologist and the perceived quality of bony landmark.

Differences between the distributions of baseline characteristics across the instruction groups were compared using Pearson’s chi-squared test or Fisher’s exact test for categorical variables or Student’s t-tests for continuous variables. The distribution of time taken was compared across intervention groups using Wilcoxon rank-sum test and linear regression of the log-transformed variable. Linear regression modelling was used to assess associations between the intervention group, potential confounders and log-time. Variables were included in the adjusted multivariable model if it was considered biologically plausible that the variable was a potential confounder of the relationship. Variables remained in the model if inclusion influenced the effect estimate of the intervention.

The secondary outcomes of interest were described using categorical variables. The association between these variables and the type of instruction given were assessed using Pearson’s chi-squared test or Fisher’s exact test where more than 20% of cells had fewer than five observations. Patient satisfaction was collapsed into two categories (dissatisfied/neutral and satisfied) and logistic regression models were fitted to determine the effect estimates for variables associated with patient satisfaction.

All analyses were performed using the Stata statistical software package (version 13) (Statacorp).

**Results**

The study population comprised of 85 patients enrolled from August 1st, 2014 to June 29th, 2016. All the patients that were enrolled for the study were analysed (Fig. 1). Out of the 85 participants, 43 received verbal instructions (Group 1) and 42 received both verbal and visual instructions (Group 2). Patients’ ages ranged from 29 to 89 years (mean: 66; SD: 11). The average BMI of the participants was 31 kg/m² (SD: 5). Summary statistics for variables of interest by interventional group are presented in Table 1.
The distribution of gender differed significantly across instruction groups but the mean age and BMI did not.

Summary statistics for outcome variables by the instruction group are presented in Table 2. The time taken for successful needle placement ranged from 30 to 2053 s. Overall, the median time taken was 227 s (3.8 min); 294 s in the verbal group in comparison to 175 s in the verbal plus visual group (Table 2). The results of univariable and multivariable linear regression of predictors on log-time are presented in Table 3. The instruction group, patient’s BMI and perceived quality of a bony landmark were significantly associated with the time taken in univariable models. In the adjusted model, instruction group remained significantly associated with time after adjusting for BMI, perceived quality of a bony landmark, age and gender. The unadjusted geometric mean time taken for the procedure using verbal instruction alone was 301 s (95% CI: 236–385) compared to 183 s (95% CI: 143–235) when both verbal and visual instructions were used. Thus, procedures were on average about 2 min and 39% shorter using the visual instructions in conjunction with the verbal instructions. Post-hoc calculations based on the log-transformed variables showed that a sample size of 44 per group would achieve 90% power at the 5% significance level to detect a difference between log-transformed mean values of 300 and 150 s, assuming a standard deviation of one for the log-transformed variable. This was consistent with the initially estimated sample size.

There were no significant differences between groups in the detailed satisfaction scores of anesthesiologists or patients (Table 2); but the majority of patients (89%) reported being satisfied or very satisfied. The results of univariable logistic regression of predictors on patient satisfaction (neutral or dissatisfied compared to satisfied) are presented in Table 4.

First-pass success was strongly associated with patient satisfaction (Odds ratio (OR): 5.2; 95% CI: 1.0–9.5). There was also some evidence that instruction group was associated with patient satisfaction (OR: 4.1; 95% CI:

| Table 1 Baseline characteristics of the patients by instruction group |
|-------------------------------------------------|----------------|----------------|---------|
| Variable & category                            | Verbal (n = 43) | Verbal and visual (n = 42) | p-value |
| Age in years (mean (SD))                       | 68 (9)         | 65 (12)        | 0.102³  |
| BMI (mean (SD)) (kg/m²)                        | 32 (5)         | 31 (5)         | 0.413³  |
| Gender (n (%))                                 |                |                | 0.037⁰  |
| Male                                           | 24 (56)        | 14 (33)        |         |
| Female                                         | 19 (44)        | 28 (67)        |         |
| Education (n (%))                              |                |                | 0.745⁰  |
| Primary                                        | 16 (37)        | 13 (31)        |         |
| Secondary                                      | 21 (49)        | 24 (57)        |         |
| Tertiary                                       | 6 (14)         | 5 (12)         |         |
| Prior spinal education³ (n (%))                 |                |                | 1.00    |
| Yes                                            | 3 (7)          | 3 (7)          |         |
| No                                             | 39 (91)        | 38 (90)        |         |
| Experience of anesthesiologist (n (%))          |                |                | 0.351⁰  |
| < 6 months                                     | 4 (9)          | 5 (12)         |         |
| 6mths - <2 years                               | 3 (7)          | 1 (2)          |         |
| 2+ years                                       | 32 (74)        | 27 (64)        |         |
| Consultant                                     | 4 (9)          | 9 (21)         |         |
| Bony landmarks (n (%))                         |                |                | 0.738⁰  |
| Clear                                          | 36 (84)        | 34 (81)        |         |
| Unclear                                        | 7 (16)         | 8 (19)         |         |

SD standard deviation, BMI body mass index

p-values derived from: *Student’s t-test; †Pearson’s chi-square test; ‡Fisher’s exact test

²Totals differ due to missing values

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Table 2: Distribution of outcomes of interest by the intervention group

| Variable & category                  | Verbal (n = 43) | Verbal and visual (n = 42) | p-value |
|-------------------------------------|-----------------|---------------------------|---------|
| Time taken (median (IQR) (seconds)) | 294 (155–625)   | 175 (116–260)             | 0.008** |
| Number of intervertebral spaces (n (%)) |                 |                           | 0.148c  |
| 1                                   | 28 (65)         | 32 (76)                   |         |
| 2                                   | 8 (19)          | 8 (19)                    |         |
| ≥ 3                                 | 6 (14)          | 1 (2)                     |         |
| Number of skin punctures (n (%))    |                 |                           | 0.001d  |
| 1                                   | 24 (56)         | 22 (54)                   |         |
| 2                                   | 4 (9)           | 15 (37)                   |         |
| ≥ 3                                 | 15 (35)         | 9 (10)                    |         |
| Number of anesthesiologists (n (%)) |                 |                           | 0.026d  |
| 1                                   | 37 (86)         | 42 (100)                  |         |
| 2                                   | 6 (14)          | 0 (0)                     |         |
| Anesthesiologist’s satisfaction (n (%)) |             |                           | 0.833c  |
| Dissatisfied                        | 5 (12)          | 3 (7)                     |         |
| Neutral                             | 6 (14)          | 5 (12)                    |         |
| Satisfied                           | 16 (37)         | 19 (45)                   |         |
| Very satisfied                      | 16 (37)         | 15 (36)                   |         |
| Patient satisfaction (n (%))        |                 |                           | 0.183d  |
| Dissatisfied                        | 1 (2)           | 1 (2)                     |         |
| Neutral                             | 6 (14)          | 1 (2)                     |         |
| Satisfied                           | 13 (30)         | 13 (31)                   |         |
| Very satisfied                      | 20 (47)         | 26 (62)                   |         |
| First pass success (n (%))          |                 |                           | 0.926c  |
| Yes                                 | 25 (58)         | 24 (57)                   |         |
| No                                  | 18 (42)         | 18 (43)                   |         |
| Successful (n (%))                  |                 |                           | 1.00d   |
| Yes                                 | 41 (95)         | 41 (98)                   |         |
| No                                  | 2 (5)           | 1 (2)                     |         |

IQR: interquartile range

*aTotals differ due to missing values

p-values derived from: bWilcoxon rank-sum test; cPearson’s chi-square test; dFisher’s exact test

Table 3: Results of linear regression of variables of interest on time taken to complete procedure (log-transformed)

| Variable & category                  | Unadjusted   | Adjusted*  |
|-------------------------------------|--------------|------------|
|                                     | Coefficient (95% CI) | p-value | Coefficient (95% CI) | p-value |
| Instruction                         |               |           |                     |        |
| Verbal                              | ref           |           | ref                 |         |
| Verbal and visual                   | −0.5 (−0.8 to −0.2) | 0.006 | −0.4 (−0.8 to −0.1) | 0.022 |
| BMI per unit (kg/m²)                | 0.05 (0.02 to 0.09) | 0.003 | 0.05 (0.01 to 0.08) | 0.007 |
| Bony landmark                       |               |           |                     |        |
| Clear                               | ref           |           | ref                 |         |
| Unclear                             | 0.5 (0.1 to 1.0) | 0.015 | 0.42 (−0.0 to 0.9) | 0.067 |

*Estimates also adjusted for age and gender
a shorter time to a successful blockade may improve the
neuraxial blocks in the future [4]. We hypothesized that
ure may increase the risk of patients refusing to have
dissatisfaction [4]. This dissatisfaction with the proced-

Table 4 Results of logistic regression of variables associated with patient satisfaction

| Variable & category | OR (95% CI) | p-value |
|--------------------|------------|---------|
| Instruction group  |            |         |
| Verbal             | Ref        |         |
| Verbal and visual  | 4.1 (0.8–21.3) | 0.089 |
| First pass success |            |         |
| No                 | Ref        |         |
| Yes                | 5.2 (1.0–9.5) | 0.049 |

0.8–21.3). However, these estimates were imprecise due
to low power for this outcome.

Discussion

Our study demonstrated that the use of a simple visual aid
in conjunction with verbal instructions resulted in im-
proved positioning of patients undergoing spinal anesthesia
as measured by significantly reduced time taken for the
procedure, improved ease of spinal needle placement with
fewer skin punctures and reduced need for assistance from
a second more experienced anesthesiologist.

The results in our study are consistent with those of a
similar study on obstetric patients undergoing epidural
anesthesia for caesarean section in which use of visual
image resulted in a reduction in both time taken and
number of needle punctures, though not statistically sig-
nificant at the 5% level. However, our study includes
general surgical patients with different demographic and
clinical characteristics.

Our observation of the univariable association between
the quality of bony landmarks and time taken is consistent
with previous studies which have shown that the quality of
the anatomical landmarks can significantly predict the de-
gree of difficulty in performing spinal anesthesia [1, 5].
However, when our results were adjusted for BMI, the ef-
effect of the quality of bony landmarks was much attenuated,
indicating the influence of BMI on the quality of landmarks.
Thus, while randomization is expected to balance the ef-
effects of potential confounders, in also fitting a multivariable
model we have assessed residual confounding, and investi-
gating the effects of other important factors such as BMI
and the presence of bony landmarks. Since we excluded pa-
tients with major spinal deformities and those with BMI
greater than 45 kg/m², although we saw a significant reduc-
tion in the number of skin punctures with the visually aided
group, we were not able to find any difference in the num-
ber of intervertebral levels attempted.

It has been previously shown that three or more at-
ttempts at spinal anesthesia, leads to significant patient
dissatisfaction [4]. This dissatisfaction with the proced-
ure may increase the risk of patients refusing to have
neuraxial blocks in the future [4]. We hypothesized that
a shorter time to a successful blockade may improve the
satisfaction of the patients and the proceduralist. In our
study, we noted that first pass success had a strongly sig-
nificant association with patient satisfaction. However,
our estimate of the magnitude of the effect was impre-
cise due to the study being underpowered to detect any
difference in satisfaction scores.

Our study has some strengths and limitations. To our
knowledge, this is the first study to consider the use of a
simple and practical aid such as visual images to assist po-
positioning for spinal blocks in a general surgical population.
Unlike the previous study [6], we have investigated the ef-
effects of possible confounders such as experience of anes-
thesiologists, educational status of patients and previous
experience with neuraxial anesthesia. We excluded pa-
tients with any prior neuraxial experience. We also did
not attempt to blind the anesthesiologists to the nature of
intervention as per earlier study [6], to ensure that we
measure the usefulness of our intervention in actual clin-
ical practice and increase external validity of our findings.
We decided to investigate its use only in spinal anesthesia
(rather than epidural anesthesia), as the free flow of CSF is
a definite endpoint that enabled us to measure the time to
success with precision [7]. However, we believe that the
results should be applicable to any neuraxial anesthesia.
Lack of anxiolytic premedication for the study participants
could have potentially limited the study’s generalizability.
We are unable to draw conclusions on whether showing
an image improved the quality of landmarks, as it was not
one of our outcomes. Additionally, as the anesthesiologists
were not blinded, this could have introduced some bias in
ascertaining the clarity of landmarks. We did not analyze
the different types or gauges of needles used or the loca-
tion of punctures (midline/paramedian) as it has been pre-
viously shown not to predict the number of attempts [1].
Moreover, the majority of the anesthesiologists at our cen-
ter choose 25 G Sprotte needle as a default first option. In
our study, as the majority (85%) of our anesthesiologists
had more than 2 years of anesthetic training we are not
able to comment on the impact of the level of experience.
However, we speculate that if more junior trainees were
included, a bigger difference in the time taken, between
the two groups may have resulted.

We are unable to comment on the utility of this ap-
proach in improving spinal anesthesia in patients with
BMI greater than 45 kg/m² or in patients with difficult
spinal anatomy as patients with these characteristics were
excluded from our study and may require ultrasound as-
sistance. However, with more than 50% of our participants
having a BMI ≥30 kg/m², we conclude that a visual aid
may also be beneficial to patients with a higher BMI. Al-
though the use of neuraxial ultrasound is on the increase
and has proven to be beneficial in patients with antici-
pated difficulties such as spinal deformities and obese pa-
tients, use of the blind landmark based technique is still
very popular. The advantage of neuraxial ultrasound in patients without difficult landmark ascertainment is questionable [9]. Hence it becomes important to advocate the use of additional easy and practical measures to improve the success rate of this procedure before neuraxial ultrasound becomes standard of care.

Conclusion
In summary, we conclude that the use of visual aids to assist positioning for neuraxial blockade reduced the time taken for the procedure by an average of 2 min and also reduced the number of skin punctures required. The use of a visual image also resulted in a 100% success rate for the first anesthesiologist without the need for a second anesthesiologist to intervene. First pass success was strongly associated with patient satisfaction.

Additional files

Additional file 1: Standardized verbal instructions. Description of the data: Standardized verbal instructions used for all the participants included commonly used phrases, agreed upon after discussion with anesthetic colleagues. (DOCX 35 kb)

Additional file 2: Visual images used for the spinal positioning. Description of the data: The visual images used in the study for the participants in group 2 included photos of one correct position and three incorrect positions. The images intended to convey the same information as the verbal instructions. (TIFF 15913 kb)

Abbreviations
BMI: Body mass index; CI: Confidence interval; CSF: Cerebrospinal fluid; OR: Odds ratio

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Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions
UG conceived of this study. UG, SK and SVA were involved in designing the methodology and the conduct of the study. KH did the statistical analysis for the study. KH and UG did the analysis and the interpretation of results. All the authors were involved in drafting the manuscript and approved the final version.

Ethics approval and consent to participate
The study was approved by the Institutional Human Research and Ethics Committee at the Prince Charles Hospital, Brisbane, Australia on the 20th December 2013 (HREC/13/QPCH/335). Written informed consent was obtained from all patients on the day of the surgery, in a form that explained the purpose and methods of the study.

Consent for publication
Written informed consent was obtained from the participants about the intention to publish as well as from the model to publish the visual images in Additional file 2.