

Spinal Nerve Block and Recovery after Spinal Anesthesia in Frail Patients - a Prospective Cohort Study

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Research

Keywords: frailty, local anesthetics, neuraxial anesthesia, pharmacodynamics

Posted Date: October 29th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-994589/v1>

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Abstract

Background

Frailty in surgical patients is associated with significantly higher incidences of perioperative mortality and complications. Although neuraxial anesthesia is preferable alternative to general anesthesia in frail patients, it remains undetermined whether the pharmacodynamic profiles of local anesthetics used in intrathecal spinal nerve blocks are altered in this population.

Methods

This prospective observational cohort study recruited 62 patients scheduled for operations that were able to be performed under spinal anesthesia between April 22 to June 30, 2020 in our hospitals. Levels of dermatome blockage after spinal anesthesia and the recovery of spinal nerve sensory and motor function were recorded.

Results

The prevalence of frailty in patients receiving spinal anesthesia in this study was 25.8%. Compared with non-frail patients, frail patients were significantly older, had a higher proportion of females, and tolerated less intense metabolic equivalent activities. The pre-surgical incision sensory blockage levels were not different between frail and non-frail patients following intrathecal administration of similar dose of bupivacaine. Time intervals to pain sensation at surgical sites (sensory recovery) and voluntary knee flexion (motor recovery) were also similar between the frail and non-frail groups. But, frail patients were associated with more episodes of hypotension and required more vasopressors during operations.

Conclusion

Our study illustrates that bupivacaine sensitivity in spinal nerve blocks is not significantly affected by frailty. However, special attention should be paid to correct intraoperative hypotension after spinal anesthesia in frail patients.

Background

Frailty is a multi-dimensional state of decreased physiologic reserve that results in diminished resiliency, loss of adaptive capacity, skeletal muscles weakness and increased vulnerability to stressors (Alvarez-Nebreda et al. 2018). The prevalence of frailty in general surgical patients ranges from 2-13%. Frailty in surgical patients is associated with significantly higher incidences of 30-day mortality, surgery-related complications, prolonged hospital stays, cognitive disorders and postoperative pain, particularly after general anesthesia (Ko. 2019; George et al. 2021). Deficits in multiple organ systems seen in frailty can result in alterations to anesthetic pharmacokinetics and pharmacodynamics (Lin et al. 2018). Changes in receptor numbers at target sites, signal transduction after receptor binding, and dysregulation of homeostatic processes can all significantly affect anesthetic pharmacodynamics in elderly or frail

patients, leading to increased or decreased drug sensitivity (Rivera et al. 2009). Since regional anesthesia reduces the need for perioperative airway manipulation and neuraxial anesthesia has been shown to be associated with improved survival and wound outcomes in frail patients (Johnson et al. 2019), regional and neuraxial anesthesia may be a preferable alternative to general anesthesia for clinical anesthesiologists (Lin et al. 2018). However, it remains unclear whether the pharmacodynamic profiles of local anesthetics used in intrathecal spinal nerve blocks are altered in patients with frailty and whether the therapeutic dose of local anesthetics should be adjusted and post-anesthesia care period extended in this population. Therefore, the primary aim of this study was to compare spinal nerve blocking responses following intrathecal administration of bupivacaine in frail and non-frail patients.

Methods

This prospective observational cohort study was approved by the institutional review board of E-Da Hospital, Taiwan. This study included patients who received elective surgery under spinal anesthesia from April 22 to June 30, 2020. This study excluded patients receiving emergency or after-hours operations and patients who were admitted to intensive care units after surgery (Figure 1). Patient frailty was assessed using Fried's 5-point frailty assessment (frail: 3-5 criteria; pre-frail: 1-2 criteria; non-frail: no positive criteria) before operation (Birkelbach et al. 2019). Anesthetic staff responsible for clinical care were blinded to the frailty status of the patients. Bupivacaine dose and the techniques used to achieve the anticipated levels of spinal nerve blockage were decided by the anesthesiologist-in-charge based on clinical practice recommendations and their personal experience. Levels of motor and sensory blockage after anesthesia were recorded by clinical nurse anesthetists. Sensory and motor blockage regression was assessed by nurses in the post-anesthesia care unit (PACU) and on the wards. Sensory recovery was defined as pain sensation at surgical sites and motor recovery period was defined as time interval to voluntary knee flexion. Incidence rates of perioperative adverse events was also noted. Matched controls were randomly selected from the non-frail population, and propensity matched with the basic patients' characteristics and types of operation in the frail group. The values of continuous variables were compared using a Wilcoxon rank-sum test and categorical variables were compared using Fisher's exact test (SPSS software, version 24.0; IBM, Armonk, NY). Statistical significance was accepted at a level of $P < 0.05$.

Results

During the study period, a total of 102 patients were scheduled for operations that were able to be performed under spinal anesthesia. 24 patients were excluded due to the operation being an emergency operation or the operation being done under general anesthesia. Therefore, a total of 81 patients were recruited and 19 patients were excluded from the final analysis due to incomplete clinical data (Figure 1). In the remaining 62 patients used in the final analysis, 16 (25.8%) of them were considered frail (Fried's score ≥ 3) (Table 1). Compared with non-frail patients, frail patients were significantly older, had a higher proportion of females, tolerated less intense metabolic equivalent (MET) activities, and had lower levels

of education (Table 1). The American Society of Anesthesiologists (ASA) physical classifications were similar between the two groups. Most of the participants undertook orthopedic or urological surgery (Table 1). After propensity matching, a total of 12 patients were selected from the non-frail patients and serve as the matched control group (Table 1). There were no differences in bupivacaine doses administered into the intrathecal space and pre-surgical incision sensory blockage levels were similar between frail and non-frail or matched non-frail patients (Table 2). However, frail patients were associated with more episodes of hypotension and required more vasopressors during operations (Table 2). Time intervals to pain sensation at surgical sites (sensory recovery) and voluntary knee flexion (motor recovery) were similar between the frail and non-frail patients (Table 2). There were no in-hospital mortality or other major postoperative events in this study.

Discussion

Consistent with other observational studies (Ko. 2019), our cohort found that frailty was more commonly diagnosed in older (mean age of 71.6 years) and female patients, and they had more limitations in their daily physical performance (MET). Since functional frailty status is not a routine consideration used in pre-anesthesia clinics for perioperative outcome predictions (Mayhew et al. 2019), this study did not find differences in the ASA physical classifications between the frail and non-frail surgical patients.

The prevalence of frailty in patients receiving spinal anesthesia in this study population was 25.8%, which is comparable with the findings of a previous larger-scale study (21.5%) (Johnson et al. 2019). The higher prevalence rates of frailty in surgical patients receiving neuraxial anesthesia over general anesthesia could simply be an implication that anesthesiologists generally consider regional blocks a safer option, associated with fewer perioperative complications in sicker and elderly patients (Lin et al. 2018; Lin et al. 2019). In a recent cohort study, the Mayo Clinic study group found that frail patients who had knee arthroplasties done under neuraxial blocks were associated with significantly lower mortality (hazard ratio 0.49; 95% CI 0.27-0.89) and wound complication rates (hazard ratio 0.71; 95% CI 0.55-0.90) in comparison to those who received general anesthesia (Johnson et al. 2019). With neuraxial anesthesia, it is important to take into consideration whether frail patients are more sensitive to local anesthetics during spinal nerve blocks (Lin et al. 2018), and if so, whether local anesthetic dosages should be reduced for spinal anesthesia.

Our study showed that sensory dermatome blockage levels achieved by similar doses of intrathecal bupivacaine were not different between frail and non-frail patients, as the anesthesiologists were blinded to patients' frailty status. Most importantly, we found that time intervals to pain sensation at the surgical site (sensory recovery) and voluntary movement of lower limbs (motor recovery) also showed no significant difference between the frail and non-frail groups, highlighting that bupivacaine sensitivity for spinal nerve blocks was not significantly affected by frailty. However, we observed more hypotensive events in frail patients and these patients also required more vasopressor therapy after spinal anesthesia. It is known that autonomic dysregulation is the main cause of developing intraoperative hypotension in the frail (James et al. 2019).

The findings of this study must be interpreted in light of several limitations. Although this was a prospective study, patients in the frail groups were older and consisted of significantly more female, which might have confounded the clinical outcomes observed during spinal anesthesia. After propensity matching, 12 non-frail patients with more identical characteristics (similar in gender, age, educational levels and smokers) were selected from the non-frail patients for matched comparison of the outcome assessments. Our results suggested that the pharmacodynamics of local anesthetics used in spinal nerve blocks are not significantly altered in frail patients even when compared with younger, predominantly male non-frail individuals. Furthermore, we do not expect elderly and frail patients to require higher doses of local anesthetics than younger patients to achieve similar levels of spinal anesthesia. Secondly, we used Fried's phenotypic criteria to assess frailty, where the frailty index has been recognized as a more comprehensive tool for multiple-domain assessment of frailty (Alvarez-Nebreda et al. 2018). Clinically, measurements using frailty phenotypes require less geriatric expertise and has a shorter assessment time. Nevertheless, the Fried's criteria employ quantitative evaluation, making it a valid subjective clinical instrument for preoperative assessment of frailty (Alvarez-Nebreda et al. 2018; Birkelbach et al. 2019). Thirdly, time to pain sensation at the surgical site was used as a surrogate indicator for sensory recovery after spinal anesthesia instead of precise measurement of spinal dermatomes. However, as patients were cared in the PACU and on the wards after surgery, surgical pain may be considered a more subjective than dermatome measurement; as spinal dermatome measurements will be done by different medical staff in the two units, leading to inconsistent interrater reliability among anesthetic, PACU, and ward personnel. Lastly, this study focused on the effects of bupivacaine and may not be generalizable to other local anesthetics.

In conclusion, our study illustrates that bupivacaine sensitivity in spinal nerve blocks is not significantly affected by frailty, even when compared with younger, male non-frail patients. However, special attention should be paid to correct intraoperative hypotension after spinal anesthesia in frail patients.

Abbreviations

ASA PC

American Society of Anesthesiologists physical class

CI

confidence interval

MET

metabolic equivalent

PACU

post-anesthesia care unit

Declarations

Ethics approval and consent to participate

The study was approved by the institutional review board (approval number EMRP-108130) of E-Da Hospital, Kaohsiung, Taiwan. Ethical approval was granted according to the Taiwan government's requirements.

Consent for publication

Not applicable

Availability of data and material

The data and materials used in the study are available on request from the corresponding author.

Competing interests

We declare that the authors have no competing interests in conducting this study.

Funding

This work was supported by research grants obtained from the Ministry of Science and Technology, Taiwan (grant number MOST 108-2314-B-650-002 to CFL) and an institutional grant obtained from the E-Da Hospital, Taiwan (EDAHP 108055 to YKS). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Authors' contributions

TLL, YKS, YCC and TSC contributed to acquisition and analysis of the data. TLL, YKS and CFL contributed to the study conception and design and the acquisition, analysis, and interpretation of the data. TLL, YKS and CFL contributed to drafting of the article.

Acknowledgements. We thank Dr Young-How Lam for editing a draft of this manuscript.

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Tables

Table 1. Patient characteristics and types of operation*

| | Frail n=16 | Non-frail n=46 | Matched non-frail (n=12) |
|-------------------------------------|---------------|---------------------------------|---------------------------------|
| Gender (M:F) | 6:10 | 32:14 [†] | 4:8 |
| Age (years) | 71.6±7.1 | 59.0±15.3 [†] | 70.6±12.9 |
| BMI (kg/m ²) | 26.6±4.2 | 26.1±3.9 | 25.8±3.8 |
| Independence in daily living | 13 (81.3) | 44 (95.7) [†] | 11 (91.7) |
| Educational level | | (<i>P</i> =0.026) [†] | (<i>P</i> =0.183) |
| Illiteracy | 4 (25.0) | 5 (10.9) | 4 (33.3) |
| < College or high school | 12 (75.0) | 32 (69.6) | 7 (58.3) |
| ≥ University | 0 (0) | 9 (19.5) | 1 (8.4) |
| Active smoker (yes) | 0 (0) | 10 (21.7) [†] | 0 (0) |
| Dietary habit | | | |
| Non-vegetarian | 15 (93.8) | 46 (100) | 12 (100) |
| Vegetarian | 1 (6.3) | 0 (0) | 0 (0) |
| Metabolic equivalent (MET) activity | | (<i>P</i> <0.001) [†] | (<i>P</i> <0.001) [†] |
| Light (<3 MET) | 16 (100) | 15 (32.6) | 3 (25.0) |
| Moderate (3-6 MET) | 0 (0) | 24 (52.2) | 9 (75.0) |
| Vigorous (>6 MET) | 0 (0) | 7 (15.2) | 0 (0) |
| ASA physical classification | | | |
| 1 and 2 | 11 (68.8) | 38 (82.6) | 9 (75.0) |
| >3 | 5 (31.3) | 8 (17.4) | 3 (25.0) |
| Type of operation | | | |
| Orthopedic | 11 (68.8) | 19 (41.3) | 5 (41.6) |
| Urology | 5 (31.3) | 22 (47.8) | 5 (41.6) |
| Colorectal | 0 (0) | 4 (8.7) | 2 (16.8) |
| Plastic | 0 (0) | 1 (2.2) | 0 (0) |

*A total of 81 patients were eligible to be recruited during the study period, and 19 patients were excluded from final analysis due to incomplete clinical data. ASA: American Society of Anesthesiologists; BMI: body mass index; F: female; M: male. Continuous data were analyzed by the Wilcoxon Whitney U test and categorical data were analyzed by the Fisher's exact test.

[†]*P*<0.05 vs frail. Results are presented as n (%) or mean±SD.

Table 2
Study outcomes

| | Frail n=16 | Non-frail n=46 | Matched non-frail n=12 | P value[§] |
|--|-----------------------|---------------------------|-----------------------------------|----------------------------|
| Dose of bupivacaine (mg)* | 10 (9-13) | 11 (7-14) | 10 (7-14) | <i>0.250/0.175</i> |
| Level of sensory block* | T9 (T5-T10) | T9 (T6-L1) | T9 (T6-L1) | <i>0.236/0.823</i> |
| Intraoperative hypotension [†] (yes) | 11 (68.8) | 17 (37.0) | 4 (33.3) | <i>0.028/0.063</i> |
| Vasopressor [‡] (yes) | 5 (31.3) | 5 (10.9) | 3 (25.0) | <i>0.070/1.000</i> |
| Time (min) to request for analgesics | | | | <i>0.646/1.000</i> |
| <60 min | 2 (12.5) | 4 (8.7) | 1 (8.3) | |
| 60-120 min | 0 (0) | 2 (4.3) | 0 (0) | |
| >120 min | 14 (87.5) | 40 (87.0) | 11 (91.7) | |
| Time (min) to knee flexion | 144.7±38.4 | 139.5±37.9 | 135.6±45.0 | <i>0.640/0.740</i> |
| Total operation time (min) | 79.4±34.6 | 64.3±34.6 | 53.8±23.6 | <i>0.138/0.043</i> |
| Intraoperative fluid (ml) | | | | <i>0.355/0.550</i> |
| 0-600 | 12 (75.0) | 36 (78.3) | 10 (83.3) | |
| 601-800 | 3 (18.8) | 8 (17.4) | 2 (16.7) | |
| >801 | 1 (6.2) | 2 (4.3) | 0 (0) | |
| [†] Intraoperative hypotension was defined as a reduction of systolic blood pressure below 25% of the baseline level before anesthesia induction. [‡] Vasopressors included bolus of ephedrine or norepinephrine to correct intraoperative hypotension. Continuous data were analyzed by the Wilcoxon Whitney U test and categorical data were analyzed by the Fisher's exact test. Results are presented as n (%) or mean±SD, and *are shown as median (range). [§] P values represent as <i>frail vs non-frail / frail vs matched non-frail</i> . | | | | |

Figures

Scheduled operations that were able to perform
under spinal anesthesia
(Jul 2020 to Aug 2020)
n=105



Exclusions:

- Emergent surgery, n=14
- General anesthesia, n=10

Eligible for inclusion
n=81



Exclusions:

- Incomplete data, n=19

Patients for final analysis
n=62

Figure 1

This study excluded patients receiving emergency or after-hours operations and patients who were admitted to intensive care units after surgery (Figure 1).