Regional Versus General Anesthesia: Effect of Anesthetic Techniques on Clinical Outcome in Lumbar Spine Surgery: A Prospective Randomized Controlled Trial

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Background: There are only a few prospective clinical trials investigating the effects of different anesthetic techniques on clinical outcomes after lumbar spine surgery. The purpose of this study was to evaluate clinical outcomes in patients receiving general (GA) and regional anesthesia (RA) for lumbar spine surgery.

Methods: This was a single-center, 2-arm, trial in which 100 patients undergoing lumbar spine surgery were randomized to receive either RA or GA (50 per group). The primary endpoint was morphine consumption during the first postoperative 48 hours. In addition, anesthesia time, transition time (defined as time from end of surgery to admission to the postoperative anesthesia care unit), visual analogue scale (VAS) for pain, and patient satisfaction at hospital discharge were recorded.

Results: There was no difference in the primary endpoint (cumulative morphine consumption at 48 h) between the 2 anesthesia types. Anesthesia and transition times were significantly shorter in the RA compared with the GA group—anesthesia time 125.4 ± 23.6 minutes for GA versus 99.4 ± 13.5 minutes for RA, transition time 22.5 minutes for GA versus 10.0 minutes for RA (both $P < 0.001$). The VAS for pain on arrival to the postoperative anesthetic care unit was lower for patients who received RA compared with GA (crude and adjusted, both <0.001). 84% of patients in the RA group were completely satisfied compared with 74% in the GA group ($P < 0.001$). There was a significant difference in the sex analysis for VAS for pain over time; females reported higher VAS for pain from the preoperative assessment to 6 weeks after the operation ($P < 0.001$).

Conclusions: There was no difference in postoperative morphine consumption in patients receiving GA and RA for lumbar spine surgery. RA was associated with shorter anesthesia and transition times, lower VAS for pain at arrival at the postoperative anesthesia care unit, and higher patient satisfaction at hospital discharge.

Key Words: spinal anesthesia, general anesthesia: lumbar spine surgery, outcome

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Lumbar spine surgery can be performed using general anesthesia (GA) or spinal-based regional anesthesia (RA). Although RA is well established in other fields of orthopedic surgery, GA is still the most commonly used anesthesia technique for lumbar spine surgery. This is because of the fact that spine surgeons and anesthetists often prefer GA, although for different reasons. Each anesthetic method has a side effect profile that affects the perioperative process in different ways. Opioids may cause nausea, vomiting, pruritus, sedation, and local anesthesia residual motor weakness in the early postoperative period.

There is insufficient evidence to quantify differences in the risk of major postoperative morbidity or mortality between RA and GA after lumbar spine surgery. A recent review identified several studies that found lower postoperative pain scores after RA compared with GA,[1] although adequately powered randomized controlled trials have provided conflicting results.[2–5] Important data, such as surgery and anesthesia times, length of stay in the postoperative anesthetic care unit (PACU) and postoperative analgesia requirements, have been inconsistently reported among studies.[6–8]

Despite a lack of conclusive evidence, there are some indications that RA is associated with lower postoperative morbidity and mortality compared with GA.[9,10] Furthermore, there are reports supporting a cost benefit of RA over GA.[11,12] The latter is mainly related to the significantly reduced anesthesia time of spinal anesthesia compared with GA in a retrospective evaluation of 473 lumbar spine surgeries.[11]

The correlation between RA and specific outcome parameters is complex and, until now, there has been no

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clear evidence for a strong recommendation to support its use over GA.[13] To help address this shortcoming, we designed this study to gain a better understanding of the relationship between the level of postoperative pain and anesthesia type. The primary aim of this randomized controlled trial was to identify differences in morphine consumption in patients undergoing lumbar spine surgery under RA or GA. We performed a prospective assessment of morphine consumption and used a visual analogue scale (VAS) to document pain intensity and changes in symptom severity over time. In addition, anesthesia and surgery times, transition time (defined as time from end of surgery to admission to the PACU), severity of postoperative nausea and vomiting (PONV), and levels of patient and surgeon satisfaction, were analyzed.

METHODS

Patients and Design

This was a single-center, 2-arm, randomized controlled superiority trial in patients undergoing elective lumbar spine surgery at the St. Anna Hospital, Lucerne, Switzerland between January 2016 and August 2016. Eligible patients were randomized to one of two study arms, to receive either a regional or general anesthesia technique during surgery. The study was conducted in accordance with the Declaration of Helsinki and ICH Good Clinical Practices Guidelines. An independent ethics committee for our institution approved the clinical protocol and informed consent documentation (EKNZ Nr. 2015-261). All patients provided written informed consent. The protocol number of the study is CTU 0524 (University of Berne/Switzerland). This study is registered at ClinicalTrials.gov (NCT03300089).

Adult patients scheduled to undergo elective lumbar spine surgery for single-level or multi-level herniated disc or spinal stenosis causing intractable pain despite conservative therapy, or motor weakness, were eligible for inclusion in the study. All surgeries were performed by the same senior neurosurgeon. Exclusion criteria included American Society of Anesthesiologists (ASA) score ≥ 4, infection at the site of the operation field, long-term (≥ 6 mo) history of neuropathic pain at the operation site, revision surgery and/or follow-up lumbar spine surgeries, severe coagulopathy (platelet count $<100{,}000/mL^3$ or thromboplastin time $<50\%$), allergy to local anesthetics or opioids, previous drug dependency or chronic use of opioids (≥ 6 mo), and psychiatric disorders precluding capacity to provide informed consent.

Demographic data, including sex, age, ASA score (I-III), body mass index (BMI) and primary diagnosis (herniated lumbar disc or spinal stenosis), were collected.

Randomization

Patients were randomized electronically to one of the 2-trial arms in a 1:1 ratio (Fig. 1). The allocation sequence was generated by an independent statistician at the Clinical trials Unit (CTU), University of Berne who was not involved in the final analysis of the data. The allocation sequence was based on computer generated

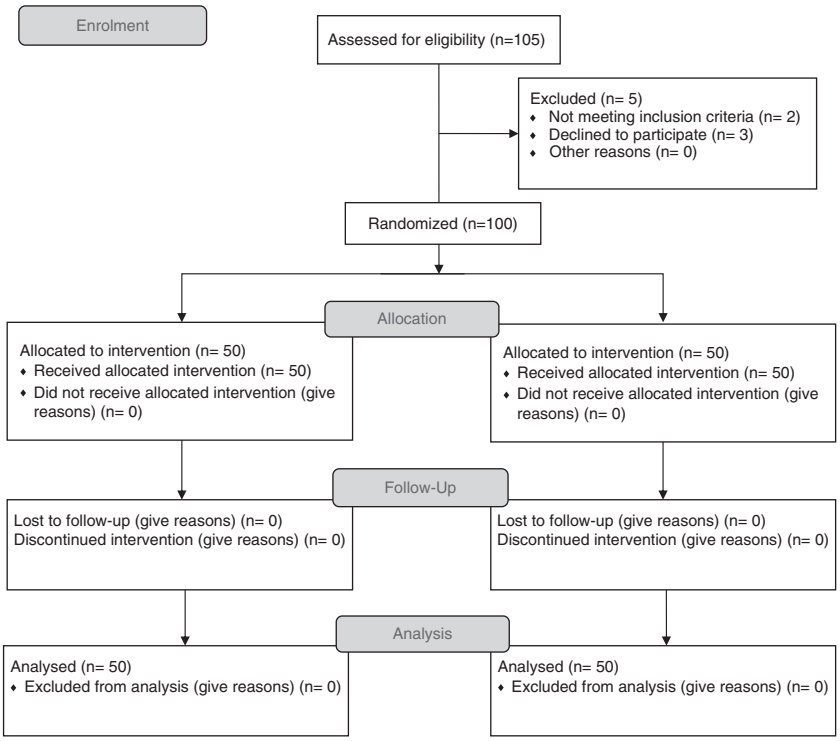

FIGURE 1. Flow-chart of patient enrolment, randomization and follow-up examination.

random numbers in randomly varying blocks of 2, 4, and 6 using the statistical software package Stata (StataCorp LP, College Station, TX). Random allocation was stratified according to whether patients presented with spinal stenosis or herniated lumbar disc (2 groups) and VAS score for pain at baseline (2 groups; VAS < 5 and VAS ≥ 5).

Blinding

It was not possible to blind the surgeon or other staff members in the operation room to the type of anesthesia given the obvious differences between GA and RA. However, the surgeon conducting the assessment of functional and clinical outcomes 6 weeks after surgery was blinded to anesthesia type. The trial statistician was also blinded to study allocations at the time of writing the statistical analysis plan, during data preparation and data validation, as well as during the primary analysis of the primary and secondary outcomes. The statistician was subsequently unblinded when secondary and further sensitivity analyses were performed.

Anesthesia Management

Patients in the GA group were anaesthetized with intravenous (IV) fentanyl 4 to 6 μg/kg and Propofol administered using a target-controlled infusion (TCI) pump to a target plasma concentration of 6 μg/mL (Schnider model). All patients underwent endotracheal intubation following a bolus of atracurium 0.5 mg/kg IV. Anesthesia was maintained with TCI Propofol targeted to a bispectral index of 40% to 50%, and remifentanil by a TCI pump to a target plasma concentration of 2 to 4 ng/mL (Minto model).

In the RA group, spinal anesthesia with 15 to 20 mg of hyperbaric bupivacaine 0.5 plus 25 μg fentanyl was administered % (using single injection technique). The L3-L4 level was preferentially used, although shifted to L2-L3 or to L4-L5 based on the level to be operated. Surgery was initiated after checking for loss of sensation to cold. During surgery, patients were mildly sedated using a continuous IV infusion of Propofol (by TCI pump) or intermittent IV boluses of midazolam.

All patients were discharged from the operating room directly to the PACU. Criteria for discharge from the PACU included a VAS for pain <4, nausea under control and (in the RA group) a sensory block below the twelfth thoracic dermatome.

Clinical Outcomes

The primary endpoint was cumulative morphine consumption at 48 hours after surgery, recorded from an IV patient-controlled analgesia (PCA) pump.

The most important secondary endpoint was pain intensity measured at rest using a VAS (0 = no pain, 10 = intolerable pain) recorded preoperatively, upon admission to the PACU, at discharge from PACU, on the first and second postoperative day, at discharge from hospital, and 6 weeks after surgery. Additional secondary endpoints included anesthesia and surgery times, length of PACU stay, incidence and severity of PONV (0 = no PONV, 4 = severe PONV) assessed at PACU arrival and discharge and at 24 and 48 hours after surgery, urinary catheterization in PACU, patient satisfaction at discharge from hospital (0 = no satisfaction, 4 = complete satisfaction), and surgeon's level of satisfaction with the anesthesia (0 = no satisfaction, 4 = complete satisfaction). The self-reported Euro Quality of Life (EQL-5D) questionnaire was used to assess patients' perception of quality of life preoperatively, at discharge, and at 6 weeks after surgery (0 = no problem, 2 = extreme problems). Adverse events (AEs) or complications, including local infection, hemorrhage, neurologic injury, or delirium, were monitored throughout the study and for up to 3 months after the 6-week-follow-up period.

Statistical Analysis

In the primary analysis, all patients were included in the full analysis set (FAS) on an intention-to-treat basis. Additional secondary analysis on the per-protocol set was unnecessary because this was identical to the FAS (no protocol violations occurred). Statistical significance for superiority was set at a 2-sided α level of 0.05. All statistical analysis was performed by a statistician at CTU Bern, using Stata 14. The minimum sample size was calculated to detect a difference in morphine consumption between treatment groups of 0.6 SDs, assuming normally distributed data. We calculated that a sample size of 45 patients per trial arm would provide 80% power to detect this difference with a 2-sided *P*-value set at 0.05 (Student *t* test). We included 50 patients per treatment arm to allow for a drop-out rate of 10%.

Baseline, procedural and postoperative data were summarized as mean ± SD (SD), median (25 to 75 percentiles), or as counts (%). *P*-values were calculated using χ^2 tests for categorical data or Wilcoxon rank tests for continuous data.

Differences between treatment groups in morphine consumption at 48 hours (the primary endpoint) were assessed using linear regression, adjusted for the stratification factors used at the time of randomization (eg, type of operation and baseline VAS < 5 vs. VAS ≥ 5). Robust standard errors were used to relax the assumption of identically distributed errors, and the distribution of the residuals of the linear model was inspected using a quantile-quantile plot. The difference in medians between the 2 groups was analyzed and adjusted for the stratification factors, as described above. This model retained the assumption of independent errors but relaxed the assumption of normal and identically distributed errors.

Secondary endpoints compared longitudinal progression of postoperative VAS for pain between treatment groups. These assessments were performed using a linear mixed model (adjusted for baseline VAS value at rest and the stratification factor diagnosis, that is, spinal stenosis and herniated lumbar disc). Fixed effects were introduced for the intervention group, time points (categorical) and interaction terms between time points and groups, as well as a random intercept for patients. Differences between

the 2 intervention groups at prespecified time points (48 h postoperative, at hospital discharge, and 6 weeks postoperative) were calculated from this model and presented with a 95% confidence interval. Moreover, the averaged difference of the 3 postoperative time points (the day of operation, 24 h postoperative and 48 h postoperative) was determined.

For other continuous secondary outcomes (anesthesia time, length of PACU stay, patient and surgeon satisfaction, and EQL-5D), the same approach as for the primary outcome was followed. EQL-5D was adjusted for baseline (preoperative) value.

In a sensitivity analysis, nonparametric approaches were used such as the stratified, rank-based van Elteren test for continuous outcomes and the stratified Cochran-Mantel-Haenszel test for binary outcomes that account for stratification factors. In a further sensitivity analysis, the difference in postoperative VAS score for pain at 24 hours, 48 hours, and at discharge was adjusted for MC and use of adjunct analgesics. Furthermore, subgroup analyses were performed in the following strata: patients with spinal stenosis versus patients with herniated lumbar disc, baseline VAS score for pain < 5 versus patients with VAS ≥ 5, male versus female patients, patients aged ≤ 40 years versus > 40 years, patients with ASA classification $\leq$ II versus $>$ II.

RESULTS

Patient Characteristics

Between January 2016 and August 2016, 46 females and 54 males with a median age of 61.5 years underwent elective lumbar spine surgery because of disc herniation (72%) or spinal stenosis (28%). There were no differences in demographics and baseline patient characteristics between the 2 groups (Table 1). In the RA group, 42% of patients were female and 58% male, 74% had a disc herniation and 26% spinal stenosis. In the GA group there was an equal number of women and men, 70% had disc herniation and 30% spinal stenosis. In total, 50% of the patients who underwent RA had a preoperative VAS score for pain ≥ 5 compared with 56% in the GA group.

No adverse events or complications were reported in either group, and no patient in the RA group had to be switched to GA.

Primary Endpoint

The overall mean postoperative morphine consumption at 48 hours after surgery was 37.5 ± 24.2 mg. Patients in the RA group received 34.3 ± 25.7 mg of morphine during the first 48 hours compared with 40.6 ± 22.3 mg in those in the GA group ($P = 0.197$, unadjusted). For postoperative morphine consumption at 48 hours, there was no significant interaction between the type of anesthesia and any of the stratification factors: sex, age, ASA classification, VAS score for pain, or type of lumbar pathology.

TABLE 1. Demographics and Baseline Characteristics

	n (%)			
	Total Group (N = 100)	GA (N = 50)	RA (N = 50)	*P*
Female	46 (46)	25 (50)	21 (42)	0.547
Male	54 (54)	25 (50)	29 (58)	
Age (y)*	61.5 (46.5; 72.0)	61.0 (48.8; 71.0)	62.5 (44.8; 75.3)	0.553
BMI	26.1 ± 4.4	26.9 ± 4.9	25.4 ± 3.7	0.07
Disc Hernia	72 (72)	35 (49)	37 (51)	0.824
Spinal Stenosis	28 (28)	15 (54)	13 (46)	
VAS at rest*	n = 100, 5.0 (2.0; 7.0)	5.0 (3.8; 7.0)	4.5 (1.8; 6.3)	0.186
VAS at rest ≥ 5	n = 100, 53 (53)	28 (56)	25 (50)	0.689

*Numbers represent median (interquartile range).
BMI indicates body mass index; GA, general anesthesia; RA, regional anesthesia; VAS, visual analogue scale for pain.

Secondary Endpoints

Perioperative data and outcome variables are shown in Table 2. Anesthesia and transition times were significantly shorter in the RA compared with the GA

TABLE 2. Perioperative Data and Outcome Variables

	n (%)		
	GA (N = 50)	RA (N = 50)	*P*
Surgery time (min)	55.7 ± 16.0	49.1 ± 13.0	0.027
Transition time (min)*	22.5 (16.0; 25.0)	10.0 (6.8; 13.3)	< 0.001
Anesthesia time (min)	125.4 ± 23.6	99.4 ± 13.5	< 0.001
PACU time (min)	100.6 ± 36.5	106.0 ± 40.3	0.426
PONV at start PACU			0.603
No PONV	47 (94)	48 (96)	
Slight PONV	2 (4)	2 (4)	
Moderate PONV	1 (2)	0 (0)	
Strong PONV	0 (0)	0 (0)	
Severe PONV	0 (0)	0 (0)	
Urinary Catheter rate	6 (12)	6 (12)	1.000
PONV at end PACU			0.563
No PONV	45 (90)	47 (94)	
Slight PONV	2 (4)	2 (4)	
Moderate PONV	1 (2)	1 (2)	
Strong PONV	2 (4)	0 (0)	
Severe PONV	0 (0)	0 (0)	
PONV 24 h after surgery			0.280
No PONV	37 (74)	44 (88)	
Slight PONV	4 (8)	3 (6)	
Moderate PONV	5 (10)	2 (4)	
Strong PONV	4 (8)	1 (2)	
Severe PONV	0 (0)	0 (0)	
PONV 48 h after surgery			0.288
No PONV	44 (88)	47 (94)	
Slight PONV	1 (2)	1 (2)	
Moderate PONV	5 (10)	1 (2)	
Strong PONV	0 (0)	1 (2)	
Severe PONV	0 (0)	0 (0)	
LOS (d)*	4.0 (3.0; 5.0)	4.0 (3.0; 5.0)	0.614

*Numbers represent median (interquartile range).
GA indicates general anesthesia; LOS, length of stay; PACU, postoperative anesthetic care unit; PONV, postoperative nausea vomiting; RA, regional anesthesia.

TABLE 3. EQL, Patient, and Surgeon Satisfaction

	n (%)		
	GA	RA	*P*
EQL baseline			0.564
No problem	0 (0)	0 (0)	
Some problem	44 (88)	42 (84)	
Extreme problem	6 (12)	8 (16)	
EQL 6 wk after surgery			0.720
No problem	32 (64)	30 (60)	
Some problem	17 (34)	19 (38)	
Extreme problem	1 (2)	1 (2)	
Patient satisfaction			< 0.001
No satisfaction	0 (0)	0 (0)	
Little satisfaction	0 (0)	0 (0)	
Good satisfaction	13 (26)	8 (16)	
Complete satisfaction	37 (74)	42 (84)	
Surgeon satisfaction			0.256
No satisfaction	0 (0)	0 (0)	
Little satisfaction	0 (0)	0 (0)	
Good satisfaction	0 (0)	5 (10)	
Complete satisfaction	50 (100)	45 (90)	

EQL indicates European quality of life; GA, general anesthesia; RA, regional anesthesia.

group: anesthesia time 125.4 ± 23.6 minutes for GA versus 99.4 ± 13.5 minutes for RA, transition time 22.5 minutes for GA versus 10.0 minutes for RA (both $P < 0.001$). Surgery time was also significantly shorter in the RA (49.1 ± 13.0 min) compared with GA (55.7 ± 16.0 min) group ($P = 0.027$).

There was no difference in the severity of PONV, rate of urinary catheterization and median length of PACU stay between the 2 groups (Table 2).

There was a higher level of patient satisfaction in the RA group. Totally, 84% of patients who received RA indicated complete and 16% good levels of satisfaction, compared with 74% and 26% who indicated complete and good levels of satisfaction, respectively, in the GA group ($P < 0.001$). There was no difference in rates of complete surgeon satisfaction between the 2 groups; 100% for GA and 90% for RA ($P = 0.256$). There was also no difference between RA and GA in quality of life (EQL-5D questionnaire) at baseline and 6 weeks after surgery (Table 3).

VAS scores over time were significantly higher for females than for males. The preoperative compared with 6 weeks postoperative scores for females were 5.1 ± 2.8 versus 0.9 ± 1.3, respectively, and, for males, 3.6 ± 2.8 versus 0.5 ± 1.1, respectively ($P < 0.001$) (Table 4). VAS scores for pain were lower in patients in the RA (0.1 ± 0.7) compared with GA (3.2 ± 3) groups at admission to PACU ($P < 0.001$ for both crude and adjusted analyses) (Fig. 2). However, there were no significant difference in VAS scores for pain at PACU discharge up to 6 weeks after surgery between younger (≤ 40 y) compared with older (> 40 y) patients, or between RA and GA (Tables 4 and 5).

DISCUSSION

This study confirms the results of previous trials demonstrating that spinal anesthesia is a safe and efficacious technique for lumbar spine surgery.[4–6] Although there was no significant difference in morphine consumption within the first 48 hours after surgery between RA and GA in our study, RA was strongly associated with lower pain scores during PACU stay, shorter anesthesia time and higher levels of patient satisfaction than GA. There have been suggestions that GA is a risk factor for development of postoperative delirium, and that this risk is not restricted to elderly patients.[13,14] Although the present study was not designed to address postoperative delirium, the recording of AEs did allow for its detection and we found no evidence of delirium in either the RA or GA group.[15]

The finding of shorter anesthesia time in the RA group in our study is congruent with the current literature.[4,6,7,12,16–18] Our finding of slightly shorter surgery time with RA is also consistent with previous reports by Jellish et al[4] and Pierce et al.[17]

The high levels of patient and surgeon satisfaction after RA in the current study have also been reported previously.[2,19] In contrast, studies by Sadrolsadat et al[5] and Kahveci et al[12] demonstrated lower surgeon satisfaction with RA. However, the study by Sadrolsadat et al[5] was a case-controlled study and not a prospective randomized controlled trial.

In contrast to our study, lower rates of PONV after RA have been reported in several other studies.[6,7,16,19,20] Only Sadrolsadat et al[5] have reported a higher percentage of patients experiencing PONV during PACU stay after

TABLE 4. VAS Scores for Pain Over Time

	Pre-op	Start PACU	End PACU	24 h Postop.	48 h Postop.	Discharge	6 wk Postop	Overall Effect*	*P**
All patients	4.3 ± 2.9	1.7 ± 2.6	1.6 ± 2.0	2.1 ± 1.9	1.5 ± 1.7	1.2 ± 1.3	0.7 ± 1.2		
GA	4.6 ± 3.1	3.2 ± 3.0	2.4 ± 2.0	2.2 ± 2.0	1.6 ± 1.5	1.4 ± 1.3	0.8 ± 1.2	−0.8 (−1.1 to −0.4)	0.230
RA	4.0 ± 2.7	0.1 ± 0.7	0.9 ± 1.7	2.1 ± 1.9	1.3 ± 1.8	1.0 ± 1.3	0.5 ± 1.2		
Male	3.6 ± 2.8	1.4 ± 2.3	1.5 ± 2.2	2.2 ± 1.8	1.4 ± 1.7	0.9 ± 0.9	0.5 ± 1.1	0.3 (−0.1 to 0.7)	< 0.001
Female	5.1 ± 2.8	2.0 ± 3.0	1.7 ± 1.8	2.1 ± 2.0	1.5 ± 1.6	1.5 ± 1.6	0.9 ± 1.3		
Years > 40	4.2 ± 2.9	1.5 ± 2.5	1.6 ± 2.1	2.2 ± 1.9	1.4 ± 1.7	1.2 ± 1.3	0.6 ± 1.1	0.3 (−0.2 to 0.9)	0.212
Years ≤ 40	4.9 ± 2.6	2.7 ± 3.1	1.8 ± 1.3	2.1 ± 2.0	1.8 ± 1.6	0.9 ± 1.0	0.9 ± 1.9		

Values expressed VAS 0 = no pain, 10 = intolerable pain.

*Adjusted for type of operation (spinal stenosis or herniated lumbar disc) and VAS score at baseline <5 versus VAS ≥ 5.

ASA indicates American Society of Anesthesiologists; GA, general anesthesia; PACU, postoperative anesthetic care unit; RA, regional anesthesia; VAS, visual analogue scale.

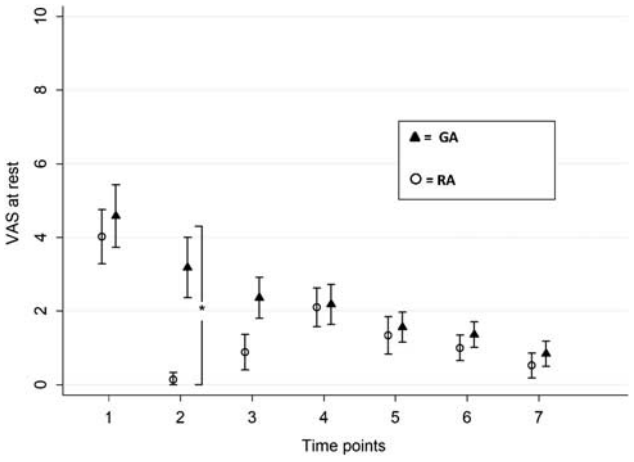

FIGURE 2. Crude mean of VAS at rest preoperatively until 6 weeks postoperatively with 95% confidence interval for GA (dark triangle) and RA (white circle) showing that RA lead to less pain postoperatively up to 2 days compared with GA. *A significant difference between the pain reported by patients operated using GA versus RA, when adjusted for type of operation (spinal stenosis or herniated lumbar disc) and VAS score at baseline <5 versus VAS ≥ 5. Time Points: 1 indicates pre-op; 2, start PACU; 3, end PACU; 4, 24 hours post-op; 5, 48 hours post-op; 6, Discharge; 7, 6 weeks post-op; GA, general anesthesia; RA, regional anesthesia; VAS, visual analogue scale for pain.

RA, although, in that study, the rate of PONV one day after surgery was lower after RA compared with GA. In contrast to the findings of Zorrilla-Vaca et al,[21] we did not identify an association between RA and reduced length of PACU stay.

It is difficult to compare our finding of no difference in 48-hour morphine consumption with previous data because there are sparse details about postoperative pain management in most studies. Sadrolsadat et al[5] and Attari et al[2] reported lower meperidine consumption after RA, but neither study specified the exact dose or time course. McLain et al[7] reported a similar pain management approach to ours with IV morphine consumption reported in mg/h, but total morphine dose and exact time periods were again not specified.

We found no difference between the RA and GA groups with regard to pain scores over time. Although this issue was not addressed in several previous studies,[2,4,6,7,12,16] consistent with our data, Vural et al[22] found no differences between RA and GA in 24-hour postoperative pain scores. These findings have been confirmed in 2 meta-analyses published in 2017 which identified statistically significant difference between RA and GA in postoperative pain scores after lumbar spine surgery.[21,23]

Two publications, by Zheng et al[24] and Gerbershagen et al,[25] investigated the influence of various factors on postoperative pain, and found a significant sex difference in the VAS pain score over time ($P < 0.001$). Such sex differences in pain levels before and after treatment are well-recognized.[26–28] In one study females presented with higher baseline pain levels before a musculoskeletal intervention, but there was no sex difference in pain scores at 1 month after treatment suggesting that females had a better response to treatment.[26] The authors of that study described the mechanism behind the fact that females had higher baseline pain score than males a "mystery." A retrospective cohort study also found a higher incidence of severe pain events in females compared with males.[29] Although women appear to be at higher risk of severe postoperative pain than men, sex differences are small overall, possibly of low clinical relevance, and several confounders might explain the discrepancies between studies.[30]

Limitations

This study has some limitations. Intrathecal fentanyl was used in the RA group in addition to local anesthesia, and there are limited data available in the current literature about the impact that this might have had on our findings.[31] Moreover, the intraoperative use of remifentanil in the GA group could have led to postoperative hyperanalgesia, but the impact of this also remains controversial based on the current literature.[32,33]

CONCLUSIONS

RA is a feasible and safe alternative to GA for elective lumbar spine surgery. Although there was a trend towards lower postoperative morphine consumption in the RA compared with GA group in this study, the difference was not statistically significant. However, RA was associated with significantly shorter anesthesia and transition times, and higher patient satisfaction compared with GA.

TABLE 5. VAS Scores for a Pain Over Time (Type of Anesthesia, Crude, and Adjusted)

	Crude			Adjusted*	
	GA	RA	*P*	Treatment Effect (95% CI)	*P*
T2 (start PACU)	3.2 ± 3	0.1 ± 0.7	< 0.001	2.48 (1.49 to 3.47)	< 0.001
T3 (end PACU)	2.4 ± 2	0.9 ± 1.7	< 0.001	0.92 (−0.07 to 1.91)	0.069
T4 (24 h post-op)	2.2 ± 2	2.1 ± 1.9	0.836	−0.48 (−1.47 to 0.51)	0.343
T5 (48 post-op)	1.6 ± 1.5	1.3 ± 1.8	0.509	−0.34 (−1.33 to 0.65)	0.502
T6 (discharge)	1.4 ± 1.3	1 ± 1.3	0.156	−0.20 (−1.19 to 0.79)	0.693
T7 (6 wk post-op)	0.8 ± 1.2	0.5 ± 1.2	0.195	−0.24 (−1.23 to 0.75)	0.636

*Adjusted for type of operation (spinal stenosis or disc herniation) and VAS score at baseline < 5 versus VAS ≥ 5.
CI indicates confidence interval; GA, general anesthesia; PACU, postoperative anesthetic care unit; RA, regional anesthesia; VAS, visual analogue scale.

The reduced transition time associated with RA may help optimize the efficiency of surgical pathways and reduce costs. A sex influence on perioperative pain and its treatment requires further clarification. Large prospective randomized controlled trials are needed to determine the optimum perioperative anesthesia protocols for lumbar spine surgery, and to resolve some of the confusions arising from the heterogeneous data in the current literature.

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