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COMPARISON OF TWO ANESTHESIA METHODS IN PERCUTANEOUS VERTEBROPLASTY FOR THE TREATMENT OF SINGLE-LEVEL OSTEOPOROTIC VERTEBRAL FRACTURES

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ABSTRACT

Objective: Vertebroplasty (VP) is a commonly used technique for the treatment of osteoporotic vertebral fractures (OVF). The aim of the study is to compare general anesthesia (GA) and local anesthesia (LA) applications for VP.

Materials and Methods: Patients who underwent VP for a single-level OVF were included in to the study. Visual analog scale (VAS), demographic characteristics, operative time, mean arterial pressure (MAP), heart rate, length of stay in intensive care and hospital, complications, side effects, kyphotic angle (KA) and anterior vertebral height (AVH) of the vertebral body were compared between groups.

Results: Eighty patients (52 female, 28 male) were included and divided into two groups: As GA, group 1, and as LA, group 2. There was statistical significant differences between preoperative VAS scores, KA, AVH compared to postoperative period in both groups ($p<0.05$). There was no difference between the groups in terms of recovery rates of these variables, complications and side effects ($p>0.05$). Heart rate and MAP was lower in group 1 ($p<0.05$).

Conclusion: VP is a minimally invasive method that provides pain relief and restoration of the fractured vertebrae. Our study showed there is no difference in the success, complication and side effect rates of VP surgeries performed with both anesthesia methods. LA may be an alternative method to GA as the primary anesthetic option for VP operations. VP can be performed under local anesthesia to avoid complications of GA and shorten the length of stay in the hospital especially in high-risk patients.

Keywords: Vertebroplasty, kyphosis angle, osteoporotic vertebral fractures, general anesthesia, local anesthesia

INTRODUCTION

Osteoporosis ranks as the second most significant public health concern worldwide, following cardiovascular diseases, according to the World Health Organization[1]. Among the various fractures associated with osteoporosis, vertebral compression fractures are the most prevalent[2]. When considering conservative treatment, concerns arise regarding the prolonged use of non-steroidal anti-inflammatory drugs, which may affect the gastrointestinal system and kidneys, as well as the potential for pressure ulcers due to extended bed rest. This raises the importance of exploring alternative approaches to expedite patient treatment and mobility[3].

In addressing osteoporotic vertebral fractures (OVFs), two commonly employed surgical techniques are vertebroplasty (VP) and kyphoplasty[4]. VP, a minimally invasive method for OVF treatment, involves the percutaneous injection of cement into the fractured vertebra[3,5]. The main goal is to promptly alleviate pain and facilitate patient mobility. VP can be performed under either local or general anesthesia. Local anesthesia is the safer and more cost-effective choice, particularly for older patients, due to its reduced risk of anesthesia-related complications[6]. However, the administration of local anesthesia provides effective communication with the patient during the procedure. Prolonged operative time, discomfort caused by body positioning, and potential toxic effects from excessive local anesthetic use are factors that may unexpectedly compromise vital functions and necessitate the termination of surgery. Conversely, the use of general anesthesia in elderly patients introduces an increased risk of complications and multiple organ dysfunction[7]. This study aimed at comparing the outcomes of VP for OVFs under both local and general anesthesia, shedding light on the optimal approach for this patient population.

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MATERIALS AND METHODS

Study Design

This retrospective controlled study received approval from the Clinical Research Ethics Committee of University of Health Sciences Turkey Trabzon Faculty of Medicine, and informed consent was obtained from all participating patients. The study involved a review of medical records for patients who underwent VP for single-level OVF between January 2018 and December 2021. Among the 125 patients who underwent percutaneous VP, inclusion criteria comprised having undergone bone densitometry examination within one year before or after the surgery, sustaining a fracture due to low-energy trauma, having no history of previous malignancy, trauma, vertebra surgery, chronic rheumatological or neurological diseases, and possessing the ability to mobilize independently before surgery. Patients without relevant medical record data, those with fractures resulting from high-energy trauma, those who underwent VP at multiple levels, or those who had concurrent surgeries were excluded from the study. Ultimately, the eligible patients were categorized into two groups: group 1, consisting of 40 patients who underwent general anesthesia, and group 2, comprising 40 patients who underwent local anesthesia.

Measurement Method

Prior to surgery, all patients underwent thoracolumbar spinal anteroposterior and lateral X-ray examinations. Postoperative thoracolumbar X-rays were conducted on the first day following the procedure. The study assessed the impact of different anesthesia methods on intraoperative mean arterial pressure (MAP) and mean heart rate, and operative time. The operative time was determined from the moment the guide needle was inserted until wound closure. VP levels were categorized into three regions: T7-T10 as the first region, T11-L2 as the second region, and L3-L5 as the third region.

Visual analogue scale (VAS) scores, ranging from 0 to 10 (with 0 indicating no pain and 10 indicating severe pain), were recorded both before and after surgery. Additionally, measurements of anterior vertebral height (AVH) and kyphotic angle (KA) were obtained from direct lateral radiographs before and after the operation. To assess the clinical effectiveness of different anesthesia methods, improvements in these parameters were calculated using the following formulas and then compared between the two groups:

1. Improvement in VAS scores (%) = [(preoperative VAS score - postoperative VAS score)/preoperative VAS score] X 100.
2. Recovery rate of AVH (%) = [(postoperative AVH - preoperative AVH)/*mean AVH] X 100.

(*mean AVH = [AVH of the upper level + AVH of the lower level]/2)

3. Recovery rate of KA (%) = [(preoperative KA - postoperative KA)/preoperative KA] X 100.

Abbreviations: *(mean AVH= [AVH of upper level+ AVH of lower level]/2).

Surgical Technique

All procedures were conducted using sterile equipment. Patients were positioned face down on the operating table after sterile preparation. Fluoroscopy was employed to pinpoint the fracture line. With the assistance of fluoroscopy, anteroposterior and lateral imaging was performed to access the vertebral body, which was then cemented using the transpedicular method. The distribution of cement within the vertebral body was verified using fluoroscopy. Once the cement had fully set, patients were repositioned to the supine position, concluding the procedure. Throughout the process, patients were continuously monitored for the risk of neurological deficits, and notably, none of the patients required a cast.

Anesthesia Method

Patients received either general or local anesthesia for the procedure. General anesthesia was performed on patients who had high anxiety levels with concerns about local anesthesia and in whom sedation in the prone position poses risks to airway safety. All patients underwent standard monitoring with electrocardiography, heart rate, MAP, and peripheral oxygen saturation. Following preoxygenation with 100% oxygen for 3 minutes, anesthesia induction was provided to all patients with intravenous 2 mg/kg propofol (propofol vial 1%) and 1 mcg/kg fentanyl. After muscle relaxation was achieved with 0.6 mg/kg rocuronium bromide, endotracheal intubation was performed. Anesthesia was maintained by inhaling a mixture of sevoflurane at 2% concentration and 60% nitrogen oxide + 40% oxygen.

Prior to local anesthesia, sedation was administered with 1 mg/kg of intravenous midazolam. Local anesthesia was performed administering 2% prilocaine hydrochloride (8 cc) to the subcutaneous tissue from the pedicle of the fractured vertebra. Various parameters were compared between the groups based on the medical records, including age, gender, fracture level, the American Society of Anesthesiologists (ASA) classification, body mass index (BMI), pre- and post-operative VAS scores, operative time, MAP, heart rate, and length of intensive care and hospital stay. Adverse anesthetic reactions were defined as vomiting, hypotension (MAP <60 mmHg), bradycardia (heart rate <60/min), and hypoxemia.

Additionally, pre- and post-operative KA and AVH measurements were derived from X-rays. The study also compared perioperative and postoperative complications between the two anesthesia groups.

Statistical Analysis

The data analysis was conducted using the SPSS software (version 22.0, Chicago, USA, 2013). Categorical data were expressed as percentages, while continuous variables were presented as mean values along with their standard deviations. Group comparisons were assessed using the Pearson chi-square test for categorical data. The normality of data distribution was examined using the Shapiro-Wilk test, Skewness, and Kurtosis

Histogram values. The relationship between non-normally distributed continuous variables and groups was analyzed using the Mann-Whitney U test.

For within-group assessments of percentage changes in VAS, KA, and AVH before and after surgery, the related samples Wilcoxon signed-rank test was employed.

RESULTS

The two groups showed no significant differences in demographic data (p>0.05). In group 1, the mean age was 77.80±4.9, consisting of 27 (67.5%) females and 13 (32.5%) males. Group 2 had a mean age of 78.55±5.94, with 25 (62.5%) females and 15 (37.5%) males (Table 1).

Table 1. Demographic data

Variables	Group 1 (n=40)	Group 2 (n=40)	p-value
Age	77.80±4.9	78.55±5.94	0.689[a]
Female Male	27 (67.5%) 13 (32.5%)	25 (62.5%) 15 (37.5%)	0.815[b]

The mean BMI was 28.60±4.77 in group 1 and 27.98±3.71 in group 2. There was no significant difference between the groups in terms of VP levels (p>0.05). Importantly, significant differences were observed in the ASA score, length of hospital stay, and operative time (p<0.05). The mean length of hospital stay was 1.93±0.764 days in group 1 and 1.55±0.749 days in group 2. The mean operative time was 45.03±9.29 minutes in group 1 and 55.28±8.44 minutes in group 2 (Table 2). The mean follow-up period of the patients after the operation was 16 months.

Parameters such as hypotension, vomiting, cement leakage, and the requirement for intensive care did not exhibit significant differences between the groups (p>0.05). Hypotension occurred in 6 (15%) patients in group 1 and 10 (25%) patients in group 2. Vomiting was observed in 9 (22.5%) patients in group 1 and 7 (17.5%) patients in group 2. Intensive care was required for 16 (40%) patients in group 1 and 11 (27.5%) patients in group 2. Cement leakage was noted in 6 (15%) patients in group 1 and 4 (10%) patients in group 2. Desaturation was absent in the general anesthesia group but affected 4 patients in the local anesthesia group. Additionally, there were significant

Table 2. Intergroup comparison

Variables	Group 1 (n=40)	Group 2 (n=40)	p-value
BMI	28.60±4.77	27.98±3.71	**0.779[a]**
Length of hospital stay (days)	1.93±0.764	1.55±0.749	**0.023[a]**
Operative time (minutes)	45.03±9.29	55.28±8.44	**0.000[a]**
VP level			
T7-T10 T11-L2 L3-L5	12 (30%) 18 (45%) 10 (25%)	12 (30%) 17 (42.5%) 11 (27.5%)	**0.978[b]**
ASA			
2 3 4	10 (25%) 26 (65%) 4 (10%)	0 20 (50%) 20 (50%)	**0.001[b]**
Hypotension (<60 mmHg)			
No Yes	34 (85%) 6 (15%)	30 (75%) 10 (25%)	**0.876[b]**
Desaturation			
No Yes	40 (100%) 0	36 (90%) 4 (10%)	**0.116[b]**
Vomiting			
No Yes	31 (77.5%) 9 (22.5%)	33 (82.5%) 7 (17.5%)	**0.781[b]**
Intensive care requirement			
No Yes	24 (60%) 16 (40%)	29 (72.5%) 11 (27.5%)	**0.344[b]**
Cement leakage			
No Yes	34 (85%) 6 (15%)	36 (90%) 4 (10%)	**0.737[b]**
MAP (mmHg)	113.75±18.90	130.25±19.28	**0.000[a]**
Heart rate	71.1±10.90	87.83±7.92	**0.000[a]**

[a]: Statistical significance between groups according to the Mann-Whitney U test, [b]: Statistical significance between groups according to the Pearson chi-square test, BMI: Body mass index, VP: Vertebroplasty, ASA: American Society of Anesthesiologists, MAP: Mean arterial pressure

differences in heart rate and blood pressure values between the groups (p<0.05). In group 1, the mean blood pressure was 113.75±18.90, while in group 2, it was 130.25±19.28. The mean heart rate in group 1 was 71.1±10.90, whereas in group 2, it was 87.83±7.92 (Table 2).

Both groups displayed significant improvements in VAS scores following surgery (p<0.05). In group 1, VAS scores shifted from 8.33±1.38 before surgery to 2.1±1.08 after surgery, while in group 2, they changed from 8.10±1.48 to 2.17±1.21 (Table 3).

The mean improvement rates in VAS scores were 72.59±19.87% in the general anesthesia group and 70.94±20% in the local anesthesia group, with no statistically significant difference (p>0.05) (Table 4).

KAs showed a significant improvement in both groups (p<0.05). In group 1, KA changed from 29.35±4.73 before surgery to 16.55±4.32 after surgery, while in group 2, it shifted from 29.65±5.74 to 15.15±4.22 (Table 3). The percentage improvement in KA showed no significant difference between the groups, with mean values of 43.42±12.31% in group 1 and 48.44±12.62% in group 2 (p>0.05) (Table 4).

Improvements in AVH collapse ratios were significant in both groups post-surgery (p<0.05). In group 1, the collapse ratio changed from 34.85±8.02% before surgery to 22.53±6.32% after surgery. In group 2, the pre- and post-operative values were 33.52±7.75% and 23.8±6.2%, respectively (Table 2). There were no significant differences between the groups regarding AVH collapse recovery rates (p>0.05), with mean values of 12,32±1.80% in group 1 and 9,87±1.32% in group 2 (Table 4).

Notably, no patients developed infection or neurological deficits, but cement leakage occurred in 7 cases into the upper and lower discs and in 3 cases into the epidural space.

DISCUSSION

The results of this study revealed no statistically significant differences in age, gender, BMI, or VP levels between the two groups. Both groups underwent the surgical procedures using the current anesthesia method, without the need for any alternative methods. Furthermore, there were no discernible distinctions between the two groups in terms of improvements in the VAS scores, correction ratios of the kyphosis angle, or anterior vertebra height. Notably, the length of hospital stay was significantly longer in the general anesthesia group. While the need for intensive care was slightly higher in group 1 (40%) compared to group 2 (27.5%), this difference did not reach statistical significance. Moreover, there were no statistically significant variations between the groups in parameters such as hypotension, desaturation, cement leakage during surgery, postoperative vomiting, and the requirement for intensive care. In essence, our study revealed that the success rates, complication rates, and side effect profiles of VP surgeries remained consistent regardless of the chosen anesthesia method.

In a separate study comparing local and general anesthesia for percutaneous kyphoplasty, the VAS scores decreased from a mean postoperative value of 6.6 to a mean postoperative 1-day value of 1.7[8]. In another study focused on percutaneous VP under local anesthesia, patient satisfaction was evaluated, with 76% of patients reporting a very good or good experience[9]. Additionally, a cohort that underwent VP using local anesthesia combined with oral sedation exhibited significantly lower level-specific verbal pain scores at the postoperative follow-up compared to preoperative scores[10]. Balkarli et al.[3] reported an 83% postoperative improvement in pain levels for patients undergoing VP under local anesthesia. Ge et al.[8] found no statistically significant differences between the local anesthesia and general anesthesia groups in patients undergoing kyphoplasty. In our series, the mean preoperative and postoperative VAS scores for the general anesthesia group were 8.33±1.38 and 2.1±1.08, respectively. In the group operated under local anesthesia, the corresponding scores were 8.10±1.48 and 2.17±1.21, respectively (p<0.05). Additionally, there were no significant differences in VAS score improvement rates between the two anesthesia methods (p<0.05). The statistical significance of this change

Table 3. Pre-and post-operative clinical and radiological findings

	Group 1 (n=40)			Group 2 (n=40)		
	Preop	Postop	p-value	Preop	Postop	p-value
VAS	8.33±1.38	2.1±1.08	0.000	8.10±1.48	2.17±1.21	0.000
KA	29.35±4.73	16.55±4.32	0.000	29.65±5.74	15.15±4.22	0.000
AVH collapse (%)	34.85±8.02	22.53±6.32	0.000	33.52±7.75	23.8±6.26	0.000

Related-samples Wilcoxon signed-rank test. VAS: Visual analog scale, KA: Kyphotic angle, AVH: Anterior vertebral height

Table 4. Comparison of recovery percentages of VAS, KA and AVH

Percentages of recovery	VAS (%)	KA (%)	AVH (%)
Group 1 (n=40)	72.59±19.87	43.42±12.31	12.32±1.80
Group 2 (n=40)	70.94±20.87	48.44±12.62	9.87±1.32
p-value	0.481	0.088	0.467

Mann-Whitney U test. VAS: Visual analog scale, KA: Kyphotic angle, AVH: Anterior vertebral height

underscores that VP is an effective method for patients with OVFs, whether performed under general anesthesia or local anesthesia.

Nerve injury arising during VP operations can be identified earlier in patients who opt for local infiltration anesthesia, as these patients remain awake and alert[8,11]. However, it is important to note that if patients are not eligible for local anesthesia, they may inadvertently move during the procedure, making surgery more challenging and prolonged, potentially leading to postoperative complications. In such cases, sedo-analgesia is often required in conjunction with local infiltration anesthesia[12]. General anesthesia with endotracheal intubation is more commonly chosen when deep sedation in the prone position poses risks to airway safety[11]. Common complications associated with VP procedures include pulmonary embolism, epidural cement extravasation leading to spinal cord or nerve root compression, infections, and adjacent vertebral fractures. In a study by Ge et al.[8], it was noted that the general anesthesia group had the highest incidence of adverse anesthetic effects, with 29.1% of patients experiencing postoperative vomiting and 38.2% reporting pharyngalgia as a secondary effect of intubation. Patients who underwent surgery with general anesthesia also had a higher requirement for intensive care[12]. Interestingly, there was no significant difference in the rate of nerve injuries between the general anesthesia group and other groups[8]. In our study, the general anesthesia group exhibited 22.5% incidence of vomiting, and a 40% need for intensive care unit (ICU) admission, whereas the local anesthesia group experienced lower rates of 17.5%, and 27.5%, respectively. Cement leakage occurred in 15% of cases in the general anesthesia group and 10% in the local anesthesia group. Desaturation was observed in only four patients who received local anesthesia. Importantly, no significant complications such as infection or neurological deficits were observed in any patient. Cement leakage occurred in 10 cases, extending into the upper and lower disc in seven cases and into the epidural space in three cases, yet it did not result in any neurological complications. These results underscore the reliability of VP when administered using both anesthesia methods for the treatment of OVFs.

Patients who receive general anesthesia tend to exhibit more stable MAP and heart rates compared to those under local anesthesia[8]. In our study, there was a notable difference in heart rate and blood pressure between the two groups ($p<0.05$), with the group undergoing general anesthesia showing lower values of mean MAP and heart rate.

Of note, patients positioned prone during surgery after local anesthesia might experience discomfort. This discomfort can sometimes result in unintended patient movements, potentially prolonging the operative time. Consequently, surgeries performed under local anesthesia generally have longer durations compared to those under general anesthesia[6,8]. Our study aligns with existing literature, revealing longer operative times in the local anesthesia group.

Studies have indicated that vertebral augmentation procedures, such as VP and kyphoplasty, can lead to improvements in AVH and correction of kyphosis[13,14]. While some studies suggest that kyphoplasty is more effective in restoring anterior height and correcting kyphosis, clinical outcomes often do not significantly differ between the two procedures[15,16]. In a study evaluating VP with different anesthesia methods, it was noted that although the degree of improvement in the kyphosis angle and AVH did not reach statistical significance, the procedure's ability to prevent the progression of kyphotic deformity was emphasized. This prevention, in turn, mitigated lung volume reduction and reduced the risk of damage to intra-abdominal organs[3]. In our study, consistent with existing literature, we observed a significant reduction in postoperative vertebral collapse rates in both the general anesthesia and local anesthesia groups.

In a study where no differences were observed between the groups concerning ASA classification, the authors reached the conclusion that the variance in postoperative ICU stay and postoperative hospital stay might be linked to the anesthesia method employed. They noted that the length of ICU and hospital stay was longer in the group receiving general anesthesia[12]. In our study, the mean length of hospital stay was shorter in the local anesthesia group, despite the longer operative times ($p<0.05$). Additionally, a significant difference existed between the groups regarding ASA scores, with a higher number of patients having higher scores in the local anesthesia group ($p<0.05$). However, there was no difference between the groups regarding the requirement for ICU admission ($p>0.05$).

Study Limitations

This study has several limitations. Firstly, the study had a retrospective nature which means that data were collected from past records, potentially introducing inherent biases and limitations associated with retrospective research. Additionally, the evaluation of VAS scores was restricted to assessments before and after surgery, with no real-time evaluations during the surgical procedure. The absence of intraoperative assessments could hinder our understanding of pain management and patient comfort during surgery. Furthermore, the study did not specify separate anesthesia durations when calculating the overall operative time, which could have provided a more precise measure of the time spent in the operating room. Lastly, the study's limited sample size may impact the generalizability of its results. To strengthen the study's conclusions and facilitate more robust statistical analyses, future research should consider larger cohorts.

CONCLUSION

In a vast number of VP patients, general anesthesia is not the first choice anesthesia method. Instead, local anesthesia serves as a potential alternative as the primary choice for

anesthesia during VP procedures. This approach can help circumvent the complications associated with general anesthesia and reduce hospital stays, particularly in cases involving high-risk patients.

Ethics

Ethics Committee Approval: This retrospective controlled study received approval from the Clinical Research Ethics Committee of University of Health Sciences Turkey Trabzon Faculty of Medicine (number: 2023/32, date: 28.09.2023).
Informed Consent: Informed consent was obtained from all participating patients.
Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: G.P., İ.A., E.K., F.S., Concept: G.P., İ.A., E.K., F.S., Design: G.P., İ.A., E.K., F.S., Data Collection or Processing: G.P., İ.A., B.S., Analysis or Interpretation: G.P., İ.A., B.S., Literature Search: G.P., B.S., Writing: G.P., İ.A.
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