Cell. Mol. Biol. (ISSN: 1165-158X)

Journal Homepage: www.cellmolbiol.org

Cellular and Molecular Biology

Original Article

Effect of acupuncture anesthesia on inflammatory response and cellular immunity in patients with osteoporotic fractures

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Article Info

Article history:

Received: March 13, 2024
Accepted: April 24, 2024
Published: August 31, 2024

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Abstract

Osteoporotic vertebral compression fractures (OVCFs) occur frequently in the elderly, with percutaneous vertebroplasty (PVP) being the major clinical treatment at present. How to improve the patient's surgical cooperation while ensuring surgical safety is the focus of clinical research. This study explores the influence of acupuncture anesthesia (AA) on the safety, inflammatory response, and cellular immunity of OVCF patients undergoing PVP, which may provide a more reliable safety guarantee for future treatment of OVCFs. The results showed that patients using AA had lower postoperative Visual Analogue Scale (VAS) scores and incidence of postoperative adverse reactions, a smaller anesthetic dosage, but an extended duration of anesthesia; moreover, the postoperative inflammatory response was markedly alleviated and the stability of T lymphocyte subsets was obviously enhanced. Therefore, AA has high clinical application value in PKP treatment of OVCFs in the future

Keywords: Osteoporotic vertebral compression fractures, Percutaneous vertebroplasty, Acupuncture anesthesia, Inflammatory response, Cellular immunity.

1. Introduction

Osteoporosis (OS) remains the most common age-related bone degeneration worldwide, with an incidence of over 36% in people over 60 years of age [1]. With the aggravation of global population aging in recent years, the incidence of OS has also shown a trend of increasing [2]. Due to various reasons such as the decline of bone density and bone quality, the destruction of bone microstructure, and the increase of bone brittleness, OS patients are highly prone to osteoporotic vertebral compression fractures (OVCFs), one of the major causes of disability in most elderly people at present [3]. Statistics have indicated a digit of over 3 million new OVCF cases worldwide in 2022 [4]. Percutaneous vertebroplasty (PVP), currently the most important clinical treatment for OVCFs, has its clinical effectiveness and safety well documented [5, 6]. As the PVP technique develops and matures and the concept of enhanced recovery after surgery (ERAS) deepens, more and more PVP procedures are completed under local infiltration anesthesia, which allows the surgeon to communicate and interact with the patient intraoperatively to evaluate the patient's current state and the safety of the operation [7]. However, due to factors such as drug reaction of anesthetics, intraoperative pain-induced stress, and psychological characteristics of elderly patients who are afraid of surgery, surgery under local anesthesia still carries certain risks and can even predispose patients to spinal anesthesia or anesthesia drug poisoning reactions due to the inadvertent entry of anesthetic drugs into the spinal canal and blood vessels [8].

Therefore, the auxiliary use of analgesics has been proposed to enhance the efficacy and safety of local anesthesia for PVP [9]. In 1958, China proposed an acupuncture anesthesia (AA) scheme based on traditional Chinese medicine, which induces stimulation at acupoints to play an analgesic role [10]. In recent years, AA-assisted local anesthesia has achieved remarkable results in clinical practice, which not only relieves patient stress responses but also better protects the stability of organ function [11, 12]. However, there is still little research to confirm its application value in PVP.

Therefore, this study conducts a preliminary observation on the clinical effect of AA in PVP treatment of OVCFs and confirms its application value, so as to provide a more reliable surgical safety guarantee for PVP in the future.

2. Materials and methods

2.1. Study subjects

One hundred and five OVCF patients admitted to our

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Doi: http://dx.doi.org/10.14715/cmb/2024.70.8.18

hospital from January 2022 to May 2023 were selected as the research subjects. All the patients underwent PVP in our hospital, of which 57 cases (control group) were treated with the conventional anesthesia scheme, and the other 48 cases (observation group) were treated with the AA-assisted anesthesia scheme. Patient clinical data in the two groups are shown in Table 1, and the difference is not statistically significant (P>0.05). This study was conducted in strict accordance with the *Declaration of Helsinki*, and all the subjects signed informed consent.

2.2. Criteria for patient enrollment and exclusion

Inclusion criteria: OVCFs confirmed by X-rays and computed tomography (CT), single-segment fracture, course of disease ≤12 months, and PVP treatment after admission. Exclusion criteria: Pathological fractures (vertebral metastases, myeloma, etc.); incomplete posterior wall of the fractured vertebra or presence of neurological symptoms associated with spinal cord compression; inconsistency between the fractured vertebra and the pain-responsible vertebra confirmed by imaging and clinical physical examinations; coagulation dysfunction, puncture area infection, skin damage, ulceration or dermatosis; pregnant women or patients suffering from serious heart disease, hypertension, mental illness, etc. and those refusing to cooperate; osteoarticular tuberculosis, osteomyelitis, vertebral infection, tumor, etc.

2.3. Surgical methods

PVP was completed by the same surgical team in our hospital. Patients received local infiltration anesthesia in a prone position. Infiltration anesthesia to the periosteum was performed by injecting 1% lidocaine into the site 1cm away from the vertebral pedicle surface projection to the surface of the articular process. A bilateral lumbar puncture was performed by transpedicular needle insertion, with the needle tip located at the lateral or center of the pedicle's "cat eye". Bilateral puncture of the thoracic vertebrae was performed transpedicularly by needle insertion through the gap between the rib head and pedicle. When the needle was in place in both anteroposterior and lateral views fluoroscopically, bone cement was injected under fluoroscopy monitoring and its dispersion in the vertebral body was observed. After injection, the wound was glued with a skin adhesive and covered with sterile dressing. The operation was completed after 10 min of observation to confirm normal activities of the patient and stable vital signs.

2.4. Anesthesia methods

The control group was given analgesics combined with local anesthesia. Thirty minutes before surgery, 40 mg of parecoxib sodium (Hunan Kelun Pharmaceutical Co., Ltd., H20171210) was intramuscularly injected. The observation group was treated with AA-assisted local anesthesia. AA was performed 20 min before surgery, and electrical stimulation was maintained during the operation. The acupuncture points selected were Hegu, Neiguan, and Zusanli. Following routine disinfection, 0.30 mm × 25 mm fine needles were used to insert 10-20mm into the above acupoints. After the patient experienced a feeling of soreness, an electroacupuncture treatment device was connected for treatment. The stimulation intensity was set based on patient tolerance, not exceeding 5mA. Routine surgical preparation was performed after 15 min of electrical stimulation.

2.5. Outcome measures

(1) Patient pain was assessed before surgery (T0), during puncture (T1), during bone cement infusion (T2), and at the end of surgery (T3) using the Visual Analogy Scale (VAS) [13] (on a 10-point scale, a higher score suggests more obvious pain). The sedation effect was evaluated with the Ramsay Sedation Score [14] (the score is directly proportional to the sedation effect based on a 1-6-point scale). The diastolic (DBP) and systolic blood pressure (SBP), as well as the heart rate (HR) of patients, were also recorded. (2) The anesthetic dosage, duration of anesthesia, and operation time were counted. (3) 3 mL of the patient's cubital vein blood was drawn into a coagulant tube before and 24 h after surgery, and the serum was obtained via centrifugation after standing at room temperature for 30 min. Enzyme-linked immunosorbent assay (ELISA) was performed to determine the levels of inflammatory factors interleukin (IL)-1β, IL-6, and tumor necrosis factor-α (TNF-α). Flow cytometry was used to measure T lymphocyte subsets $CD3^+$, $CD4^+$, and $CD8^+$. (4) The occurrence of adverse effects from postoperative to discharge was counted, and the total incidence rate was calculated.

2.6. Statistical methods

Statistical analysis was performed using SPSS24.0. The chi-square test was used to compare count data expressed as [n(%)]. Measurement data, described as ($\bar{\chi}$±s), were comparatively analyzed between groups with the independent sample t-test and within groups with the paired t-test. The threshold of statistical significance was P<0.05.

3. Results

3.1. Comparison of anesthetic effects

The two groups were not markedly different in VAS scores at T0-T3 (P>0.05); however, the VAS scores at T1, T2, and T3 were lower in the observation group compared with the control group (P<0.05). In both groups, the VAS score was higher at T1 than at T0, increased continuously

Table 1. Comparison of clinical data.

Group	Male	Female	Thoracic vertebrae fracture	Lumbar fracture	Age	Time from onset to surgery (d)
Control group (n=57)	22 (38.60)	35 (61.40)	35 (61.40)	22 (38.60)	52.47±7.74	10.74±4.19
Experimental group (n=48)	15 (31.25)	33 (68.75)	28 (58.33)	20 (41.67)	53.17±7.58	10.65±3.78
χ^2 (or t)	0.616		0.102		0.461	0.116
P	0.432		0.749		0.646	0.908

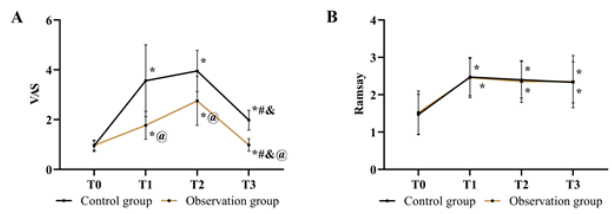

Fig. 1. Comparison of anesthetic effects. (A) VAS score, (B) Ramsay score. Note: *vs.* T0 *P<0.05, *vs.*T1 #P<0.05, *vs.* T2 &P<0.05, control group @P<0.05.

at T2, and decreased at T3 (P<0.05); while the Ramsay score was higher at T1 than at T0 (P<0.05) and remained unchanged at T2 and T3 in both groups (P>0.05, Fig 1).

3.2. Comparison of vital signs

The vital signs were not statistically different between groups across the time points (P>0.05). In both groups, SBP decreased and DBP increased at T1-T3 (P<0.05), while HR did not change significantly at T0-T3 (P>0.05, Fig 2).

3.3. Comparison of surgical conditions

The anesthetic dosage, duration of anesthesia, and operation time in the observation group were (8.24±2.50) mg, (61.61±19.03) min, and (51.52±10.42) min respectively, while those in the control group were (10.98±4.20) mg, (71.42±13.61) min, and (51.56±12.44) min, respectively. The above data revealed no notable inter-group difference in operation time (P>0.05), but the anesthetic dosage was lower and the duration of anesthesia was higher in the observation group compared with the control group (P<0.05, Fig 3).

3.4. Comparison of inflammatory responses

There was no significant inter-group difference in preoperative inflammatory factors (P>0.05). After surgery, IL-1β, IL-6, and TNF-α in both groups increased and were even lower in the observation group (P<0.05, Fig 4).

3.5. Comparison of cellular immunity

Similarly, the two groups showed no marked difference in preoperative T lymphocyte subsets (P>0.05). The observation group had reduced $CD3^+$ and $CD4^+$ after surgery, still higher than those in the control group, and elevated $CD8^+$ (P<0.05, Fig 5).

3.6. Comparison of safety

Both groups of patients successfully completed the operation. The incidence of adverse reactions in the control group was 14.04%; 1 patient developed lidocaine anaphylaxis, and the blood pressure decreased rapidly from 180 mmHg before surgery to 90 mmHg when the infiltration was complete; there were also 7 patients experiencing dizziness and palpitation accompanied by nausea and vomiting of varying degrees during the operation. The incidence of adverse reactions in the observation group was 2.08%. The above data showed a lower incidence of adverse reactions in the observation group versus the control group (P<0.05, Tab 2).

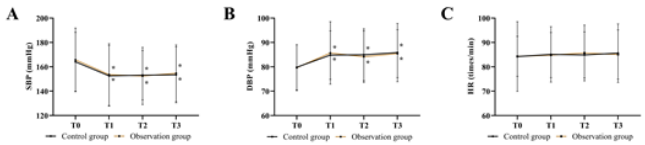

Fig. 2. Comparison of vital signs. (A) SBP, (B) DBP, (C) HR. Note: *vs.* T0 *P<0.05, *vs.*T1 #P<0.05, *vs.* T2 &P<0.05, control group @ P<0.05.

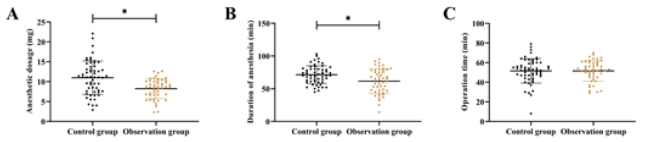

Fig. 3. Comparison of surgical conditions. (A) anesthetic dosage, (B) duration of anesthesia, (C) operation time. Note: *P<0.05.

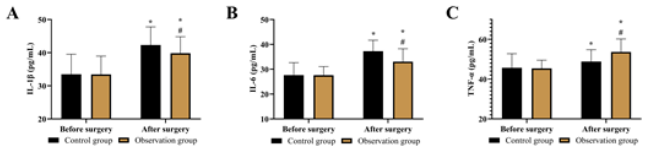

Fig. 4. Comparison of inflammatory responses. (A) IL-1β, (B) IL-6, (C) TNF-α. Note: *vs.* Before surgery *P<0.05, *vs.* control groups #P<0.05.

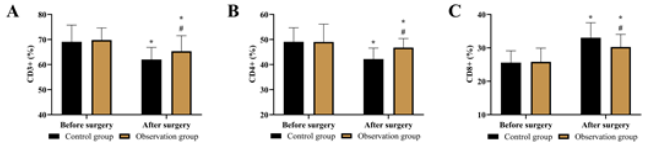

Fig. 5. Comparison of cellular immunity. (A) CD3+, (B) CD4+, (C) CD8+. Note: *vs.* Before surgery *P<0.05, *vs.* control groups #P<0.05.

4. Discussion

OVCFs are a major disease affecting the normal life of the elderly, and safe and effective treatment is of great significance to ensure patient prognoses [15]. In virtue of high safety and excellent auxiliary anesthesia effects, AA has been increasingly concerned in surgical procedures [16]. In this study, the anesthesia status of the two groups was compared, and no marked difference was found in

Table 2. Comparison of incidence of adverse reactions.

Group	Low blood pressure	Dizziness	Panic	Nausea and vomiting	Total incidence
Control group (n=57)	1 (1.75)	3 (5.26)	2 (3.51)	2 (3.51)	14.04
Experimental group (n=48)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.08)	2.08
χ^2					4.750
P					0.029

Ramsay scores, suggesting the stable and reliable effects of both anesthesia methods in analgesia and sedation. Among them, the VAS scores at T1-T3 were lower in the observation group than in the control group, which suggests that AA can more effectively relieve intraoperative pain. Acupuncture stimulates the meridians through acupoints to transmit the circulation of Qi and blood in the organs, allowing the body to maintain a smooth flow of Qi and blood in the organs and meridians during surgery, thus exerting analgesic and regulatory effects on physiological disorders [17]. The AA process has been shown to promote the patient's body to produce endogenous analgesic substances, and the output wave can stimulate the release of enkephalins, achieving the effect of sedation and anesthesia [18]. In this study, the selection of acupoints and adjunct acupuncture points was based on the traditional Chinese medicine theory. Hegu and Neiguan, commonly used acupoints for AA, disperse collaterals in the heart system and can calm the heart and soothe the nerves, strengthen the spleen and nourish the liver, reduce Qi and regulate the stomach, and relieve pain. Therefore, with the assistance of AA, patients in the observation group achieved more significant analgesic effects. The study of Zhang W et al. also showed that AA has an excellent analgesic effect on patients undergoing thyroid surgery [18], which can also support the results of this study. In addition, in the comparison of vital signs, we can see that the intraoperative SBP, DBP, and HR changes were not significant between groups, indicating that AA does not cause significant cardiovascular burden and has a stable and reliable effect, which is also due to the fact that AA has no toxic and side effects. Moreover, in previous studies, we also found that the use of AA can more effectively promote the stability of blood pressure during thoracic surgery [19], further confirming the important clinical application value of AA. Furthermore, the decrease in anesthetic dosage in the observation group indicates that AA can reduce the dosage of anesthetic drugs. This is because acupuncture can stimulate the muscles of high threshold and small diameter nerves by regulating the nervous system and the release of peptide-based neurotransmitters, and activate endogenous opioid peptides in the brain to release endogenous opioid peptides from neurons, thus playing an analgesic role [20]. During acupuncture, signals are transmitted to the spinal cord and reach the midbrain via afferent pathways. Through neurochemical and hormonal changes, the flow and integration of these signals between specific brain regions generate pain perception and may lead to altered pain perception [21].

On the other hand, stress damage of organs and tissues caused by surgery is the key cause of postoperative complications, which seriously affects the prognosis of patients [22]. In this study, stress damage was assessed by inflammatory responses and cellular immunity. Both groups showed elevated levels of inflammatory factors after surgery compared to preoperative levels, as well as changes and disorders in T lymphocyte subsets, confirming the presence of obvious stress reactions after surgery, namely intensified inflammation and disruption of cellular immunity [23]. However, the inter-group comparison showed lower postoperative levels of inflammatory factors in the observation group and smaller changes in T lymphocyte subsets, indicating milder inflammation, better cellular immunity, and less surgery-induced stress damage than the control group. We hypothesize that this is also due to the fact that AA has less potential damage to patients. As we all know, the anesthetic mechanism of traditional anesthetics is mainly to block the transmission of neurotransmitters to achieve the effect of pain inhibition [24]. However, after the complete metabolism of anesthetic drugs, the body inevitably needs to secrete a large amount of adrenaline to relieve postoperative stress and trauma [25], which directly causes the disorder of the endocrine environment and accelerates the transmission of inflammatory factors. The high safety of AA can effectively avoid postoperative changes in the endocrine environment and always maintain the internal stability of the body, thus circumventing the risk of intensified inflammatory responses and imbalance of cellular immunity. In addition, narcotic drugs are usually metabolized by the liver and kidneys, and the increase in the anesthetic dosage may not only cause a greater burden on the hepatorenal function after the operation that induces dysfunction, but also induce abnormal changes in the heart beat that triggers serious postoperative complications [26]. In this study, we also observed a decrease in the incidence of complications in the observation group compared to the control group, which further confirms the high safety of AA in PVP, consistent with the research results of Ang JY et al. in exploring the safety of AA [27]. However, the duration of anesthesia was found to be longer in the observation group, which is due to the need to start surgical treatment after the appearance of acupuncture sensation. Therefore, the anesthesia time required by AA combined with local anesthesia is longer than that of local anesthesia combined with anti-inflammatory analgesics or central analgesics, which is in line with the objective law.

In summary, in the treatment of OVCFs with PVP, AA-assisted local anesthesia has similar effects on maintaining the stability of vital signs as analgesics combined with local anesthesia, but it can improve the analgesic effect and safety, reduce the dosage of anesthetic drugs, and improve the postoperative liver and kidney function of patients, although the anesthesia time is extended.

Current clinical evidence suggests that AA has the advantages of protecting the body and reducing the cost of anesthesia [28]. According to the results of this paper, we believe that AA-assisted anesthesia should be given priority in PVP if it can meet the anesthesia requirements. However, the selection of acupuncture points and stimulation methods is particularly important in AA. Given the absence of unified guidelines for the application of AA-assisted anesthesia in PVP, it is necessary to be guided by experienced Chinese medicine practitioners and closely monitor changes in the vital signs of perioperative patients when performing AA. In the follow-up study, we will also try to find the superior acupoints and stimulation methods of AA in PVP by adjusting acupoints and stimulation methods, so as to obtain better analgesia, sedation, and safety. The number of samples and the research period will also be increased to enhance the credibility of the application of AA in PVP.

Consent to publish

All authors gave final approval of the version to be published.

Competing interests

The authors report no conflict of interest.

Author contributions

Jianmin Li and Dong Zhang conceived and designed the project, and wrote the paper. Zhichao Ge generated the data. Kai Lv and Hao Sun analyzed the data. Jiajun Wu and Shuqiang Wang modified the manuscript. All authors gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Funding

Not applicable.

Acknowledgements

Not applicable.

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