

Comparison of remifentanyl with dexmedetomidine for monitored anaesthesia care in elderly patients during vertebroplasty and kyphoplasty

Jung Min Lee, Soo Kyung Lee, Sang Jun Lee, Woon Suk Hwang, Sung Wook Jang and Eun Young Park

Abstract

Objectives: This randomized, prospective double-blind study compared remifentanyl with dexmedetomidine for monitored anaesthesia care during minimally invasive corrections of vertebral compression fractures (vertebroplasty or kyphoplasty).

Methods: Patients > 65 years of age with American Society of Anesthesiologists (ASA) classification I–III, scheduled for vertebroplasty or kyphoplasty under monitored anaesthesia care, received remifentanyl (i.v. infusion 1–5 µg/kg/h) or dexmedetomidine (loading dose 0.3–0.4 µg/kg followed by i.v. infusion 0.2–1 µg/kg/h) to maintain observer’s assessment of alertness/sedation (OAA/S) scale <4 during the procedure.

Results: There were no statistically significant differences in demographic data between the remifentanyl ($n=37$) and dexmedetomidine groups ($n=38$). Patients on dexmedetomidine experienced lower mean arterial pressure (MAP) and heart rate (HR), and higher SpO₂ values, than patients on remifentanyl. Compared with dexmedetomidine, remifentanyl produced more respiratory depression, oxygen desaturation, and reduced the need for additional intraoperative opioids. There were no significant between-group differences in terms of recovery time, investigators’ satisfaction scores, or patients’ overall pain experiences.

Conclusions: During monitored anaesthesia care, dexmedetomidine provides less respiratory depression, lower MAP and HR, but also less analgesic effect than remifentanyl in elderly patients undergoing vertebroplasty or kyphoplasty.

Department of Anaesthesiology and Pain Medicine, Hallym University Sacred Heart Hospital, College of Medicine, Hallym University, Anyang, Republic of Korea

This clinical trial is registered at *ClinicalTrials.gov*. (NCT02476981)

Corresponding author:

Eun Young Park, Department of Anaesthesiology and Pain Medicine, Hallym University Sacred Heart Hospital, 22, Gwanpyeong-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do 431-796, Republic of Korea.

Email: parkey00@hallym.or.kr



Keywords

Remifentanil, dexmedetomidine, vertebroplasty, kyphoplasty, monitored anaesthesia care; elderly

Date received: 22 May 2015; accepted: 24 August 2015

Introduction

Compression fractures of the spine are common causes of disability among the elderly¹ and are often treated by the minimally invasive procedures, vertebroplasty or kyphoplasty.² In these procedures, bone cement is injected percutaneously into the fractured vertebra. Local anaesthesia for vertebroplasty is effective, well tolerated and easy to use. However, for kyphoplasty (which is a more technically complex procedure than vertebroplasty), patients may feel more pain and may move, making the anaesthesia more problematic and so increase its duration.³ Although general anaesthesia for vertebroplasty and kyphoplasty provides a good surgical condition and comfort for both patients and physicians, these spinal procedures are commonly performed in elderly people who have decreased cardiopulmonary function. In addition, these procedures are performed in the prone position, which may increase the risk of anaesthesia-related cardiopulmonary complications. Monitored anaesthesia care, which controls the patients' anxiety and pain without need for an intervention to maintain respiratory and cardiac function,⁴ may be more appropriate than general anaesthesia for elderly patients. However, the use of sedatives in patients in the prone position, especially if they are elderly, may induce respiratory depression and make airway management difficult.^{5,6}

Of the sedatives available for monitored anaesthesia care, benzodiazepines, propofol and opioids are most frequently used.⁷ Propofol and remifentanil are commonly used because of their rapid onset and short duration of action,^{8,9} and their good tolerability.¹⁰ However, interaction and

synergism between these drugs may result in oxygen desaturation and hypoxaemia during the procedure.⁷ Dexmedetomidine is a highly selective α -2 adrenergic agonist with both sedative and analgesic properties that rarely causes respiratory depression.¹¹

To our knowledge, no reported study has compared remifentanil with dexmedetomidine during vertebroplasty or kyphoplasty. Therefore, we compared the effects of remifentanil with dexmedetomidine during monitored anaesthesia care for the two spinal procedures in elderly patients. Treatments were assessed in terms of effects on the patients' haemodynamic stability and respiratory condition. Following each procedure, we also recorded investigators' satisfaction scores and patients' overall pain experience.

Patients and Methods

Patients

This randomized, prospective, double-blind study was approved by the Institutional Review Board of Hallym University Sacred Heart Hospital. All patients provided written informed consent. The study was registered retrospectively because during its inception trial registration was not mandatory.

Patients who were scheduled for vertebroplasty or kyphoplasty under monitored anaesthesia care, and had an American Society of Anesthesiologists (ASA) status classification of I–III,¹² and were >65 years of age, were randomly assigned to receive remifentanil or dexmedetomidine in equally sized groups using a computer-generated random-numbers programme. Patients with obesity (defined as a body mass index [BMI] > 30 kg/m²), hypotension (systolic

blood pressure [BP] < 100 mmHg), bradycardia (heart rate (HR) < 60 beats per min), heart block, baseline oxygen desaturation (SpO_2 < 90%), sleep apnoea, asthma, or chronic obstructive pulmonary disease, and those who refused to give informed consent, were excluded from the study.

Procedures

All patients fasted for 8 h before the procedure and were premedicated with intravenous (i.v.) midazolam 0.02 mg/kg. During the procedure, patients were monitored in the prone position by standard electrocardiogram (ECG), noninvasive BP assessments and pulse oximetry, and received supplemental oxygen (3 l/min) via a nasal cannula.

Study treatments were prepared by one of the authors (S.K.L.) in 20-ml and 50-ml syringes. Initially all patients received an i.v. bolus dose of propofol 0.3 mg/kg. Patients allocated dexmedetomidine received an i.v. loading dose at 0.3–0.4 $\mu\text{g}/\text{kg}$, administered from a 20-ml syringe over 10 min, followed by a continuous i.v. infusion of dexmedetomidine 0.2–1 $\mu\text{g}/\text{kg}/\text{h}$ from a 50 ml syringe. To maintain the double-blind nature of procedures, patients allocated remifentanyl received i.v. saline for the loading dose (administered from a 20-ml syringe over 10 min), followed by a continuous i.v. infusion of remifentanyl at 1–5 $\mu\text{g}/\text{kg}/\text{h}$ from a 50-ml syringe. Levels of patient sedation were checked during the procedure and infusion rates were adjusted to maintain alertness/sedation below 4 on the Observer's assessment of alertness/sedation (OAA/S) scale (Table 1).¹³ Mean arterial pressure (MAP), heart rate (HR), SpO_2 , respiratory rate (RR), and adverse effects of the study drugs were recorded by independent assessors (S.K.L.) at every step during the procedure (i.e., T_0 , baseline; T_1 , lidocaine infiltration; T_2 , trocar insertion; T_3 , cement insertion; T_4 , skin closure). Ephedrine 5 mg or 10 mg was injected i.v. if systolic BP

Table 1. Observer's assessment of alert/sedation (OAA/S) scale used to assess level of sedation¹³

Response scale	Level
Responds readily to name spoken in normal tone (awake/alert)	5
Lethargic response to name spoken in normal tone	4
Responds only after name spoken loudly or repeatedly	3
Responds after mild prodding or shaking	2
Does not respond to mild prodding or shaking (asleep/unrousable)	1

decreased below 90 mmHg; atropine 0.5 mg was injected i.v. if HR fell below 60 beats per min.

The incidences of oxygen desaturation and respiratory depression were recorded, as were trends of oxygen saturation and RR. Oxygen desaturation was defined as SpO_2 < 93% for > 10 s; respiratory depression was defined as RR < 12/min. In the event of SpO_2 < 90%, patients received oxygen via a facial mask instead of the nasal cannula, oxygen delivery was increased from 3 to 7 l/min and airway assistance manoeuvres were performed. Patients were asked to assess their level of pain during the procedure using a visual analogue scale (VAS) which spanned 0 (no pain) to 10 (worst possible pain). Those who scored VAS \geq 5 were given additional i.v. fentanyl 0.5–1 $\mu\text{g}/\text{kg}$ despite maximal infusion of the study drug. Patients were discharged from the postanaesthesia care unit (PACU) when the postanaesthetic Aldrete recovery score¹⁴ was \geq 9. The duration of PACU stay was recorded and prolonged duration of PACU stay was defined as > 60 min.

Investigators' satisfaction scores (0; extensive movement and complaints, several interruptions; 1, movements, two interruptions; 2, small movements, no interruptions;

3, no movements, no interruptions) and patients' overall pain experience (0, no pain; 1, mild; 2, moderate; 3, severe) were also recorded after the procedures by independent assessors.

Statistical analyses

In a previous study, the incidence of oxygen desaturation in the remifentanyl group was 40%.³ Therefore, it was estimated that 32 patients in each group were required to detect a difference between treatments, assuming that patients on dexmedetomidine achieve a 75% risk reduction compared with those on remifentanyl ($\alpha=0.05$, power=0.8). Assuming a 20% dropout rate, the final sample size was estimated to be 40 patients in each group. Statistical analyses were performed using SPSS[®] software (version 22.0 for Windows[®]; IBM, Somers, NY, USA).

Haemodynamic and respiratory data were analysed using repeated-measures analysis of variance (ANOVA) and intergroup differences at the same time point were analysed using a two-sample *t*-test. Investigators' satisfaction scores and patients' overall pain experience were

assessed using Mann–Whitney *U*-test. A two-sample *t*-test was used to analyse recovery time between the two treatment groups. Fisher's exact test was used to analyse the incidences of adverse effects. Data were presented as mean \pm SD or median (interquartile range). *P*-values < 0.05 were considered to indicate statistical significance.

Results

In total, 80 elderly patients were recruited into the study and five were excluded due to baseline oxygen desaturation. There were no statistically significant differences in demographic or clinical characteristics between patients in the remifentanyl group ($n=37$) and those in the dexmedetomidine group ($n=38$) (Table 2).

Haemodynamic and respiratory variables at each surgical step are shown in Figure 1. There were no statistically significant intergroup differences in MAP, HR, SpO₂, or RR at T₀. However, repeated-measures ANOVA showed that over the remaining study period, MAP (Figure 1a; $P=0.013$) and HR (Figure 1b; $P=0.003$) were statistically significantly lower in the dexmedetomidine group than in the remifentanyl group.

Table 2. Demographic data from the comparison of remifentanyl with dexmedetomidine for monitored anaesthesia care in elderly patients during vertebroplasty and kyphoplasty

Characteristic	Remifentanyl	Dexmedetomidine
Number of patients	37	38
Sex, male: female	2 : 35	4 : 34
Age, years	77.1 \pm 7.4	75.4 \pm 6.4
Weight, kg	54.5 \pm 9.7	57.4 \pm 9.8
Height, cm	151.8 \pm 5.7	153.5 \pm 7.7
Duration of surgery, min	45.5 \pm 9.7	45.1 \pm 9.0
ASA class		
I	3	2
II	15	14
III	19	22

Data presented as mean \pm SD or *n* patients.
ASA: American Society of Anesthesiologists¹²

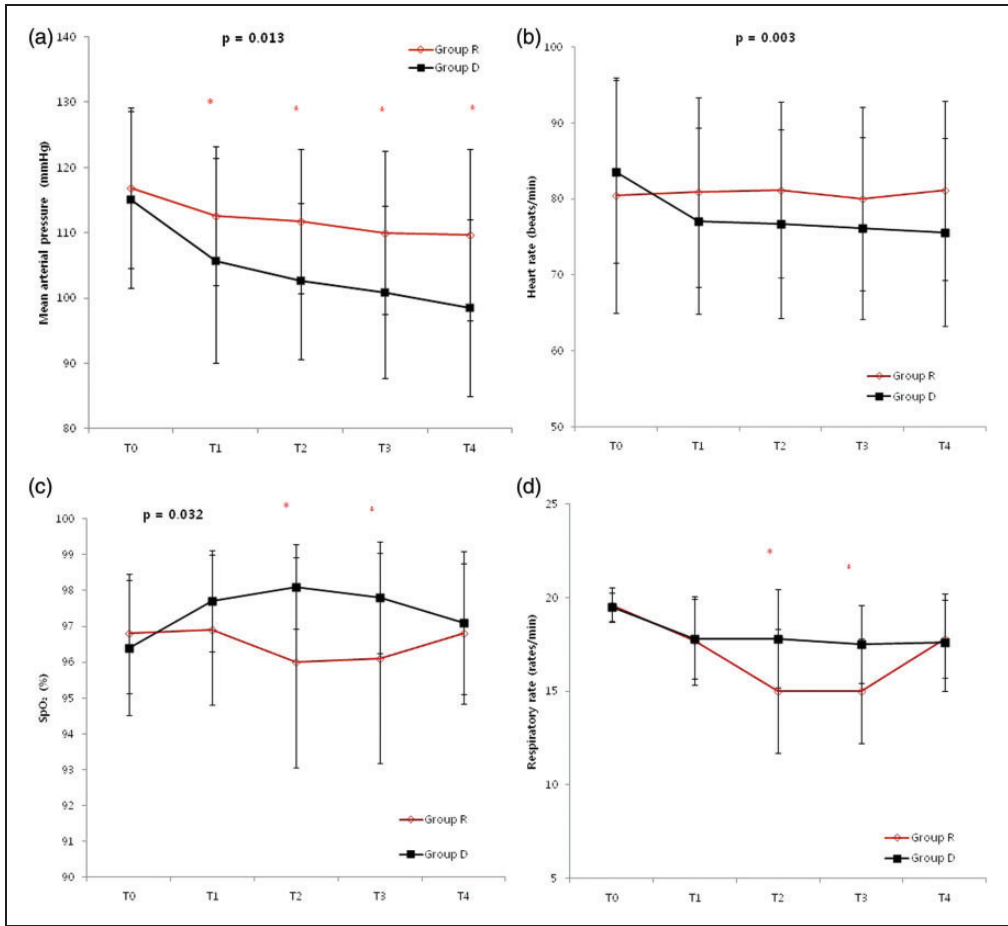


Figure 1. Changes in (a) mean arterial pressure (MAP), (b) heart rate (HR), (c) oxygen desaturation (SpO₂) and (d) respiratory rate (RR) in patients >65 years of age receiving remifentanyl and dexmedetomidine during vertebroplasty or kyphoplasty (T₀, baseline; T₁, lidocaine infiltration; T₂, trocar insertion; T₃, cement insertion; T₄, skin closure). Variables of MAP, HR and SpO₂ showed significant difference over time between both groups, using repeated-measures analysis of variance (ANOVA). Intergroup differences at the same time point were analysed using a two-sample t-test (*P < 0.05)

For MAP, significant differences between treatments were observed at all time points. For SpO₂, repeated-measures ANOVA showed that values were statistically significantly lower in the remifentanyl group than in the dexmedetomidine group (Figure 1c; P = 0.032), particularly at T₂ (96.0 ± 2.9 vs. 98.1 ± 1.2) and T₃ (96.1 ± 2.9% vs. 97.8 ± 1.6%). Overall, there was no statistically significant difference in RR during the

procedure (Figure 1d; P-value = 0.6), but at T₂ and T₃, RR was statistically significantly lower in the remifentanyl group (15.0 ± 3.3, 15.0 ± 2.8 rpm) than in the dexmedetomidine group (17.8 ± 2.6, 17.5 ± 2.1 rpm) (Figure 1d; P-values ≥ 0.05).

Adverse effects of the study drugs included oxygen desaturation, respiratory depression, nausea/vomiting, additional fentanyl administration, hypotension and

Table 3. Adverse effects of remifentanyl and dexmedetomidine for monitored anaesthesia care in the elderly during vertebroplasty and kyphoplasty

Adverse effects	Remifentanyl (continuous i.v. infusion of 1–5 µg/kg/h) (n = 37)	Dexmedetomidine (i.v. loading dose at 0.3–0.4 µg/kg followed by a continuous i.v. infusion of 0.2–1 µg/kg/h) (n = 38)	Statistical significance ^a
Oxygen desaturation	13 (35.1)	5 (13.2)	P = 0.026
Respiratory depression	15 (40.0)	2 (5.3)	P < 0.0001
Nausea/vomiting	4 (10.8)	0	NS
Additional fentanyl administration	0	7 (18.4)	P = 0.012
Hypotension	0	2 (5.3)	NS
Prolonged duration of PACU stay	0	1 (2.6)	NS

Data presented as n (%) patients.

^aFisher's exact test.

NS: not statistically significant ($P > 0.05$).

prolonged recovery time (Table 3). The incidences of oxygen desaturation and respiratory depression were higher with remifentanyl than with dexmedetomidine ($P = 0.026$ for oxygen desaturation, and $P < 0.0001$ for respiratory depression). In the remifentanyl group, no patients complained of pain during the procedure, whereas seven patients in the dexmedetomidine group complained of pain ($VAS \geq 5$) and received additional fentanyl. The difference between the two treatments was statistically significant ($P = 0.012$). The incidences of hypotension and prolonged duration of PACU stay were higher with dexmedetomidine than with remifentanyl, but intra- or postoperative nausea or vomiting rates were higher with remifentanyl (four reports) than dexmedetomidine (no reports), but the differences were not statistically significant. The two patients in the dexmedetomidine group who developed hypotension received ephedrine (one patient received 5 mg; the other received 10 mg) to maintain systolic BP > 90 mmHg. No patient required atropine for bradycardia.

No statistically significant between-group differences were detected in the investigators' satisfaction scores (for both

treatments, median score was 2 [interquartile range, 2–3]), patients' overall pain experience (remifentanyl median score, 1 [range 1–1]; dexmedetomidine median score, 1 [range 1–2]), or duration of PACU stay (21.49 ± 8.57 min, 21.84 ± 11.59 min).

Discussion

In this study, haemodynamic variables, adverse effects and other parameters were compared in elderly patients undergoing vertebroplasty or kyphoplasty under monitored anaesthesia care using remifentanyl or dexmedetomidine. The findings showed that patients who received remifentanyl were less likely to require additional opioids for pain control. However, compared with patients on dexmedetomidine, they had higher MAP and HR, lower SpO₂, and more respiratory depression.

Few studies have examined vertebroplasty or kyphoplasty under monitored anaesthesia care. Mohr et al.¹⁵ reported that i.v. piritramide and midazolam during kyphoplasty were well tolerated and useful for their sedative and analgesic properties; Della Puppa et al.¹⁶ reported that continuous i.v. infusion of propofol and

intermittent fentanyl injection were well tolerated and effective during vertebroplasty or kyphoplasty.

Remifentanyl is known to be useful for spinal procedures under monitored anaesthesia care: its continuous infusion has been shown to provide better analgesia than intraosseous lidocaine alone or intermittent fentanyl injection during some spinal procedures.^{17,18} Dexmedetomidine has been reported to be an effective and well tolerated sedative in patients undergoing a variety of procedures (orthopaedic, ophthalmic, plastic, vascular stent, breast biopsies, hernias, arteriovenous fistulae and excision of lesions) under monitored anaesthesia care.¹⁹ However, the use of dexmedetomidine in spinal procedures has not been reported; nor has a comparison of the drug with remifentanyl been documented. For this study, the chosen maintenance i.v. doses of remifentanyl (1–5 µg/kg/h) and dexmedetomidine (0.2–1 µg/kg/h) were based on previous studies where they have been reported to provide adequate sedation.^{7,20–23} Although there was no difference in patient overall pain experience between groups, the need for additional opioids during the procedure was higher in those on dexmedetomidine than in those on remifentanyl, indicating that dexmedetomidine alone did not effectively control pain for patients undergoing vertebroplasty or kyphoplasty. Ryu et al.⁷ reported that patients who underwent flexible bronchoscopy under continuous infusion of dexmedetomidine required more frequent administration of topical anaesthesia than those undergoing the procedure on remifentanyl. In addition, in another study, dexmedetomidine lacked the analgesic effects of alfentanil at a plasma concentration that produced mild-to-severe sedation.²⁴ Although dexmedetomidine is known to have strong analgesic properties,¹¹ it appears to be weaker than opioids in this respect. The results from this current study suggest that continuous infusion with

dexmedetomidine alone does not appear to be a satisfactory option in spinal procedures.

All patients who underwent vertebroplasty or kyphoplasty in this study were elderly and would have been expected to have reduced lung capacity. Furthermore, the procedures were performed in the prone position, which results in thoracic compression and decreased functional residual capacity which also may have contributed to deoxygenation.⁵ Additionally, depending on the number of treated vertebrae, fat and bone marrow or cement embolism may have also contributed to decreased arterial PO₂.⁵ Moreover, sedatives may worsen oxygenation and increase right ventricular afterload due to hypercapnia,³ emphasizing the anaesthesiologist's role in maintaining adequate patient respiration during monitored anaesthesia care.

Overall, patients' SpO₂ was >95%, and there was no statistical difference between the two groups in RR. However, RR values at T₂ and T₃ were lower in patients receiving remifentanyl than in those receiving dexmedetomidine, leading to a greater incidence of respiratory depression and oxygen desaturation. Although remifentanyl appears to suppress patient respiration more than dexmedetomidine,¹¹ its depressive effects may be alleviated by increased oxygen delivery or verbal stimuli.

Both MAP and HR were lower with dexmedetomidine than remifentanyl, probably due to the sympatholytic action²⁵ and suppression of catecholamine levels by dexmedetomidine.²⁶ Studies that recorded haemodynamic variables following these treatments showed similar findings.^{23,27,28} Although in this current study, the analgesic effect of dexmedetomidine was lower than that of remifentanyl, dexmedetomidine had a relatively greater effect on haemodynamic variables than remifentanyl. Hypotension and bradycardia are known haemodynamic effects of dexmedetomidine and are associated with loading dose and infusion time.²⁹

However, in this current study, MAP was maintained over 60 mmHg and the two patients who developed hypotension on dexmedetomidine were readily treated with ephedrine 5–10 mg. These results suggest that careful monitoring of haemodynamic changes is advised when using dexmedetomidine in elderly patients because they are more likely to have comorbidities compared with younger patients.

There was no statistical difference between the groups in investigators' satisfaction scores or patients' overall pain experience. Unlike general anaesthesia, most patients under monitored anaesthesia care are conscious and response to painful stimuli, so they tend to move and cause disturbances in situations of insufficient analgesia. However, most patients underwent the procedures with few movements and no disturbance. This might have been due to the additional fentanyl injections in patients receiving dexmedetomidine despite its lesser analgesic properties.

Previous studies that have compared recovery time of remifentanyl with that of dexmedetomidine have yielded conflicting results. Ryu et al.⁷ reported that patients who underwent flexible bronchoscopy sedated by a bolus i.v. dose of 0.2 µg/kg dexmedetomidine followed by its continuous i.v. infusion 0.4–2 µg/kg/h showed longer recovery times than those on remifentanyl. Likewise, Park et al.²³ reported that patients undergoing cataract surgery had a longer recovery time after 0.5 µg/kg dexmedetomidine over 10 min followed by i.v. infusion at 0.2 µg/kg/h than those on remifentanyl. However, Na et al.²¹ reported that patients' sedation scores were well maintained during cataract surgery with dexmedetomidine 0.6 µg/kg/h with no loading dose; in these patients, discharge was not delayed. In the present study, the relatively low loading dose of dexmedetomidine (0.3–0.4 µg/kg) and the low continuous i.v.

infusion (0.2–1 µg/kg/h) did not induce profound sedation. In addition, the prolongation of recovery time due to oversedation was not statistically significant between the two study groups.

A limitation of this study was the lack of continuous monitoring of partial pressure of oxygen or carbon dioxide during the procedures. Although pulse oximetry and RR monitoring were convenient methods to assess oxygenation, intra-arterial blood gas analysis or end-tidal CO₂ monitoring would have been more sensitive methods to detect respiratory depression and oxygenation. However, serial arterial blood gas analysis would perhaps have been too invasive for these elderly patients undergoing monitored anaesthesia care. In addition, end tidal CO₂ monitoring via a nasal cannula or facial mask in the prone position is sometimes inaccurate because of impaired sample collection.

In conclusion, both remifentanyl and dexmedetomidine are well tolerated for monitored anaesthesia care in elderly patients undergoing vertebroplasty or kyphoplasty. Compared with remifentanyl, dexmedetomidine induced less respiratory depression and produced a lower MAP, and HR. Therefore, dexmedetomidine may be an attractive choice for monitored anaesthesia care during vertebroplasty and kyphoplasty in elderly patients. However, the drug was less effective in inducing analgesia than remifentanyl and was associated with more frequent need for intraoperative opioids.

Acknowledgements

We would like to acknowledge the support of medical staff at the Spine Centre (particularly Drs Seok Woo Kim and Yong Chan Kim), and residents at Hallym University Sacred Heart Hospital, for their co-operation during patient recruitment.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Nevitt MC, Ettinger B, Black DM, et al. The association of radiographically detected vertebral fractures with back pain and function: a prospective study. *Ann Intern Med* 1998; 128: 793–800.
2. Cauley JA, Hochberg MC, Lui LY, et al. Long-term risk of incident vertebral fractures. *JAMA* 2007; 298: 2761–2767.
3. Luginbühl M. Percutaneous vertebroplasty, kyphoplasty and lordoplasty: implication for the anesthesiologist. *Curr Opin Anaesthesiol* 2008; 21: 504–513.
4. Sen J and Sen B. A comparative study on monitored anesthesia care. *Anesth Essays Res* 2014; 8: 313–318.
5. Uemura A, Numaguchi Y, Matsusako M, et al. Effect on partial pressure of oxygen in arterial blood in percutaneous vertebroplasty. *AJNR Am J Neuroradiol* 2007; 28: 567–569.
6. Kim KH. Safe sedation and hypnosis using dexmedetomidine for minimally invasive spine surgery in a prone position. *Korean J Pain* 2014; 27: 313–320.
7. Ryu JH, Lee SW, Lee JH, et al. Randomized double-blind study of remifentanyl and dexmedetomidine for flexible bronchoscopy. *Br J Anaesth* 2012; 108: 503–511.
8. Davies L, Mister R, Spence DP, et al. Cardiovascular consequences of fiberoptic bronchoscopy. *Eur Respir J* 1997; 10: 695–698.
9. Glass PS, Hardman D, Kamiyama Y, et al. Preliminary pharmacokinetics and pharmacodynamics of an ultra-short-acting opioid: remifentanyl. *Anesth Analg* 1993; 77: 1031–1040.
10. Holas A, Krafft P, Marcovic M, et al. Remifentanyl, propofol or both for conscious sedation during eye surgery under regional anaesthesia. *Eur J Anaesthesiol* 1999; 16: 741–748.
11. Hsu YW, Cortinez LI, Robertson KM, et al. Dexmedetomidine pharmacodynamics: part I. crossover comparison of the respiratory effects of dexmedetomidine and remifentanyl in healthy volunteers. *Anesthesiology* 2004; 101: 1066–1076.
12. Miller RD, Cohen NH, Eriksson LI, et al.. *Miller's Anesthesia*, 8th ed. Philadelphia: Elsevier, 2015, p.1144.
13. Patki A and Shelgaonkar VC. A comparison of equisedative infusions of propofol and midazolam for conscious sedation during spinal anesthesia – a prospective randomized study. *J Anaesthesiol Clin Pharmacol* 2011; 27: 47–53.
14. Miller RD, Cohen NH, Eriksson LI, et al.. *Miller's Anesthesia*, 8th ed. Philadelphia: Elsevier, 2015, p.2942.
15. Mohr M, Pillich D, Kirsch M, et al. Percutaneous balloon kyphoplasty with the patient under intravenous analgesia and sedation: a feasibility study. *AJNR Am J Neuroradiol* 2011; 32: 649–653.
16. Della Puppa A, Andreula C and Frass M. Assisted sedation: a safe and easy method for pain-free percutaneous vertebroplasty. *Minerva Anestesiol* 2008; 74: 57–62.
17. Dauri M, Coniglione F, Faria S, et al. Continuous i.v. infusion of remifentanyl and intraosseous lidocaine provide better analgesia than intraosseous lidocaine alone in percutaneous vertebroplasty of osteoporotic fractures. *Br J Anaesth* 2009; 103: 901–902.
18. Hwang KI, Lee HY, Shim KD, et al. Analgesia-based sedation using remifentanyl during percutaneous endoscopic lumbar discectomy. *Korean J Anesthesiol* 2006; 50: 36–41.
19. Candiotti KA, Bergese SD, Bokesch PM, et al. Monitored anesthesia care with dexmedetomidine: a prospective, randomized, double-blind, multicenter trial. *Anesth Analg* 2010; 110: 47–56.

20. Alhashemi JA. Dexmedetomidine vs midazolam for monitored anaesthesia care during cataract surgery. *Br J Anaesth* 2006; 96: 722–726.
21. Na HS, Song IA, Park HS, et al. Dexmedetomidine is effective for monitored anesthesia care in outpatients undergoing cataract surgery. *Korean J Anesthesiol* 2011; 61: 453–459.
22. Hu R, Liu JX and Jiang H. Dexmedetomidine versus remifentanyl sedation during awake fiberoptic nasotracheal intubation: a double-blinded randomized controlled trial. *J Anesth* 2013; 27: 211–217.
23. Park JH and Kwon JY. Remifentanyl or dexmedetomidine for monitored anesthesia care during cataract surgery under topical anesthesia. *Korean J Anesthesiol* 2012; 63: 92–93.
24. Angst MS, Ramaswamy B, Davis MF, et al. Comparative analgesic and mental effects of increasing plasma concentration of dexmedetomidine and alfentanil in humans. *Anesthesiology* 2004; 101: 744–752.
25. Bekker A, Sturaitis M, Bloom M, et al. The effect of dexmedetomidine on perioperative hemodynamics in patients undergoing craniotomy. *Anesth Analg* 2008; 107: 1340–1347.
26. Singh S and Singh A. Dexmedetomidine induced catecholamine suppression in pheochromocytoma. *J Nat Sci Biol Med* 2014; 5: 182–183.
27. Özcan AA, Özyurt Y, Saraçoğlu A, et al. Dexmedetomidine versus remifentanyl for controlled hypotensive anesthesia in functional endoscopic sinus surgery. *Turk J Anesth Reanim* 2012; 40: 257–261.
28. GümüşF, Şinikoğlu SN, Erkalp K, et al. The analgesic and hemodynamic effects of dexmedetomidine and remifentanyl during chest tube removal. *Turkish J Thorac Cardiovasc Surg* 2013; 21: 966–971.
29. Miller RD, Cohen NH, Eriksson LI, et al. *Miller's Anesthesia*, 8th ed. Philadelphia: Elsevier, 2015, p.858.