

# Regional anesthesia techniques in orthopedic surgery

## Abstract

**Background:** The effect of regional anesthesia techniques on orthopedic surgeries is very actual topic in current clinical practice.

**Aim:** The aim of this review article was to research regional anesthesia techniques for postoperative pain control and outcomes in orthopedic surgeries.

**Methods:** The English literature was reviewed based on a search regional anesthesia and orthopedic surgery in clinical studies.

**Major findings:** A number of authors proposed that regional anesthesia in orthopedic patients may be associated with better postoperative pain control and a reduction in intraoperative blood loss when compared with general anesthesia.

**Conclusion:** In the future regional anesthesia techniques will be more preferable anesthetic technique in orthopedic surgeries.

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## Introduction

Regional anesthesia techniques have been increasingly used in orthopedic surgery procedures. Regional anesthesia techniques can be classified as central neuraxial blocks including spinal and epidural anesthesia, peripheral nerve blocks including upper extremity and lower extremity blocks and regional intravenous anesthesia (RIVA) (Table 1). In many clinical studies have been reported that regional anesthesia techniques provided important advantages when compared with general anesthesia in orthopedic surgeries. Regional anesthesia techniques are not only performed for adequate anesthesia in the orthopedic surgical procedures. They have also other advantages including excellent postoperative pain control, reduced side effects, decreased blood loss, and shortened stay in the postanesthesia care unit (PACU).<sup>1-5</sup>

## Methods

The English literature was reviewed based on a search regional anesthesia and orthopedic surgeries in clinical studies and case reports.

## Results

### Shoulder surgery

Regional anesthesia techniques such as interscalene brachial plexus block and continuous Interscalene brachial plexus block were used in shoulder surgery procedures. In some clinical studies were demonstrated that interscalene brachial plexus block was often used to provide anaesthesia and analgesia for shoulder surgery.<sup>6,7</sup> When prolonging the block with a patient-controlled interscalene analgesia (PCIA) infusion 0.15% bupivacaine or ropivacaine provided adequate pain control and high patient satisfaction after shoulder surgery.<sup>7</sup> In a mini review article was reported that when considering the effectiveness of pain control, the incidence of side effect, and the patient satisfaction patient-controlled interscalene analgesia may be superior after shoulder surgery.<sup>8</sup>

### Hand and forearm surgery

Hand and wrist surgeries are usually performed on outpatient status. In a clinical study, Hadzic et al.<sup>9</sup> reported that infraclavicular

brachial plexus block with a short-acting local anesthetic produced time-efficient anesthesia, faster recovery, fewer adverse events, better analgesia, and greater patient acceptance than general anesthesia followed by wound infiltration with a local anesthetic in outpatients undergoing hand and wrist surgery. Intravenous regional anesthesia (IVRA) is generally performed in hand, wrist and forearm surgeries of the upper extremity. Some clinical studies demonstrated that the addition of analgesics to the local anesthetics during IVRA decreased tourniquet pain and increased anesthesia quality in hand and forearm surgeries.<sup>10-12</sup>

### Hip joint

The common regional anesthesia techniques for total hip arthroplasty (THA) were combined spinal-epidural block, epidural block and catheter, and spinal block with sedation. There was controversy as to whether total hip replacement was best performed under neuraxial block, including epidural and spinal block, or general anesthesia.<sup>13</sup> Hypotensive epidural anesthesia (HEA) was one of the anesthetic techniques used to reduce perioperative blood loss and transfusion requirements in hip surgeries. In a clinical study, Eroglu et al.<sup>4</sup> reported that in spite the similar mean arterial pressure (50-60mmHg) levels noted between groups, HEA resulted in less intraoperative blood loss than HTIVA during primary total hip replacement. Macfarlane et al.<sup>14</sup> performed a systematic review of the literature to compare general anesthesia (GA) and regional anesthesia (RA) and also systemic and regional analgesia for THA. Their systematic review did suggest that blood loss reduced in patients receiving RA rather than GA for THA. Regional analgesia did, however, reduce postoperative pain and also nausea and vomiting. Length of stay was not reduced and rehabilitation did not appear to be facilitated by RA or analgesia for THA.

### Knee surgery

Total knee arthroplasty (TKA) is a common procedure and it may cause significant pain in the acute postoperative period. The results of some studies suggested that regional anesthesia may control the postoperative pain.<sup>15</sup> However, there were few data in the literature to support the hypothesis that regional anesthesia had any effect on functional outcome.<sup>16</sup> Femur neck fracture surgery: Regional

anesthesia techniques such as low dose of spinal anesthesia, combined spinal epidural anesthesia were successfully used for femur fracture surgeries in some case reports.<sup>17-19</sup>

### Foot and ankle surgery

Some types of lower extremity peripheral nerve blocks were used for foot and ankle surgery.<sup>20</sup>

## Discussion

### Shoulder surgery

Shoulder surgery is often associated with severe postoperative pain, particularly within the first 48 hours. Postoperative pain after shoulder surgery can cause patient discomfort as well as compromise functional recovery. Adequate pain relief after shoulder surgery is necessary both for the comfort of the patients and for an early use of rehabilitation exercise.<sup>8</sup> In some clinical studies have been demonstrated that interscalene brachial plexus block is often used to provide anaesthesia and analgesia for shoulder surgery.<sup>6,7</sup> When prolonging the block with a patient-controlled interscalene analgesia (PCIA) infusion 0.15% bupivacaine or ropivacaine provide adequate pain control, and high patient satisfaction after shoulder surgery.<sup>7</sup> In two clinical studies Borgeat and colleagues reported that the use of PCIA both with 0.15% bupivacaine and 0.2% ropivacaine were demonstrated to provide better quality of pain control, decreased incidence of side effects such as vomiting and pruritus than PCA with opioids after major shoulder surgery.<sup>21,22</sup> In another one study Borgeat et al.<sup>23</sup> reported that PCIA with 0.2% ropivacaine and 0.15% bupivacaine provided a similar pain relief after major shoulder surgery. Eroglu<sup>24</sup> compared some analgesics and techniques after open shoulder surgery. In this study Eroglu<sup>24</sup> reported that the PCA techniques using subacromial ropivacaine or fentanyl i.v. provided similar and adequate pain relief and minimal side effects after open acromioplasty surgery. But, the PCA using subacromial fentanyl was not as effective as either subacromial ropivacaine or i.v. fentanyl.

Patient-controlled postoperative analgesia techniques using interscalene, subacromial, and intravenous catheter were compared in a mini review article after shoulder surgery. As a conclusion of the review article have reported that when considering the effectiveness of pain control, the incidence of side effect, and the patient satisfaction patient-controlled interscalene analgesia may be superior.<sup>8</sup>

### Hand and forearm surgery

Hand and wrist surgeries are usually performed on outpatient status. Some of the regional anesthesia techniques have been used for the surgeries of the upper extremities. The use of peripheral nerve blocks may have some potential benefits in the outpatient status and result in a lower risk of nausea or vomiting, earlier ambulation, enhanced pain relief, and earlier discharge when compared with general anesthesia. Hadzic et al.<sup>9</sup> compared with infraclavicular brachial plexus block performed with a short-acting local anesthetic and a “fast-track” general anesthesia performed with propofol and desflurane in an outpatient hand or wrist surgery. They reported that infraclavicular brachial plexus block with a short-acting local anesthetic produced time-efficient anesthesia, faster recovery, fewer adverse events, better analgesia, and greater patient acceptance than general anesthesia followed by wound infiltration with a local anesthetic in outpatients undergoing hand and wrist surgery.

Intravenous regional anesthesia (IVRA) is generally performed in hand, wrist and forearm surgeries of the upper extremity. It has

some advantages for example providing a blood-free surgery site, an easy applicability, a rapid termination of the anesthetic effect when compared with general anesthesia. Some clinical studies demonstrated that the addition of analgesics to the local anesthetics during IVRA decreased tourniquet pain and increased anesthesia quality in hand and forearm surgeries.<sup>10-12</sup>

### Hip joint

The common regional anesthetic techniques for hip arthroplasty are combined spinal-epidural block, epidural block and catheter, and spinal block with sedation. Mauer mann et al.<sup>13</sup> performed a meta-analysis to test the hypothesis that elective total hip replacement (THR) under neuraxial block was associated with improved outcomes compared with the surgery under general anesthesia. They focused their analysis on elective THR to reduce many confounding factors, such as blood loss before the procedure, in patients with hip fracture and trauma. They chose to analyze intraoperative outcome measurements including operative time, estimated intraoperative blood loss, and transfusion requirements and intra- and postoperative outcome measurements such as number of patients with deep venous thrombosis (DVT), pulmonary embolism (PE), and mortality. As a summary, their data indicated that neuraxial block was associated with a decrease in intra-operative blood loss and the number of patients requiring blood transfusions. It is not known whether some of the beneficial effects such as reduced incidence of DVT and PE provided by neuraxial block are applicable to today's practice when compared with investigations performed 20 years ago. However, their findings indicated that neuraxial block should be considered as a valid and potentially beneficial technique for elective THR.

In another meta-analysis Memtsoudis et al.<sup>25</sup> studied a large national sample of primary joint arthroplasty recipients and hypothesized that neuraxial anesthesia favorably influences perioperative outcomes. They reported that data collected between 2006 and 2010 were obtained from Premier Perspective, Inc. (Charlotte, NC), an administrative database containing information on discharges from approximately 400 acute care hospitals located throughout the United States. In conclusion, their analysis of this large nationwide sample provided evidence of the superior comparative effectiveness of neuraxial versus general anesthesia in the setting of primary hip and knee arthroplasty. Multiple outcomes including perioperative complications and length of hospital stay were positively affected by the choice of neuraxial versus general anesthesia. Many outcome benefits were reduced, but still significant when combining general with neuraxial anesthesia. They also reported that their data therefore offer evidence of benefit associated with neuraxial anesthesia and support further research to study the mechanisms by which beneficial effects may be exerted.

On the other side, the use of neuraxial or peripheral nerve blockade may expose patients to the risk of perioperative nerve injury (PNI). Perioperative nerve injury (PNI) is a serious adverse complication of total hip arthroplasty (THA) and it is associated with needle- or catheter-induced mechanical trauma, local anesthetic neurotoxicity, and the blunting of protective reflexes within an anesthetized extremity.<sup>26-28</sup> The risk for PNI is higher for orthopedic surgical procedures than for other surgical interventions for example vascular surgery.<sup>29</sup> The overall incidence of neurologic complications after regional anesthesia for lower extremity procedures has been estimated to be between 0.03% and 1.5%.<sup>30,31</sup> However, it is unclear if the risk for neurologic complications is comparable between central neuraxial techniques and peripheral techniques.<sup>29-31</sup> Previous studies evaluating perioperative nerve injury (PNI) have some limitations including the

lack of a standardized definition for PNI, the inclusion of patients undergoing a broad range of surgical procedures, the assessment of specific surgical procedural factors, the assessment of patient-related risk factors and the variability in which PNI was assessed.<sup>32</sup> Jacob et al.<sup>33</sup> aimed to test the hypothesis that the use of regional anesthesia increases the risk for PNI after elective THA in a single-institution, large-scale, single-procedural cohort study. They reported that the use of peripheral nerve blockade or neuraxial anesthesia did not increase the risk of postoperative neurologic complications in patients undergoing elective THA.

Hypotensive epidural anesthesia (HEA) is one of the anesthetic techniques used to reduce perioperative blood loss and transfusion requirements in hip surgeries. In a clinical study, Eroglu et al.<sup>4</sup> compared hypotensive epidural anesthesia (HEA) and hypotensive total intravenous anesthesia (HTIVA) with propofol and remifentanyl on blood loss during primary total hip replacement. They reported that in spite the similar mean arterial pressure (50–60 mmHg) levels noted between groups, HEA resulted in less intraoperative blood loss than HTIVA during primary total hip replacement. This outcome may be associated with non-positive pressure ventilation, distribution of blood flow, and lower mean intraoperative central venous pressure in the HEA group.<sup>4</sup>

In a clinical study post-operative continuous epidural infusion in geriatric patients with cardiopulmonary co-morbidities was used to control postoperative pain in orthopedic surgeries. From the study the authors concluded that both levobupivacaine (0.2%) and ropivacaine (0.2%) can be used as continuous epidural infusion owing to postoperative pain free period with stable hemodynamic profile and no side effect.<sup>34</sup>

**Table 1** Some of the regional anesthesia techniques using in orthopedic surgery

Regional anesthesia technique	Type of the block
Central Neuraxial Blocks	- Single or continuous epidural block
-Epidural	- Single shut spinal block
- Spinal	- Continuous spinal block
	- Combined spinal-epidural block
Peripheral Nerve Blocks	- Interscalene brachial plexus block
-Upper extremity	- Continuous Interscalene brachial plexus block
- Lower extremity	- Axillary blocks
	- Continuous axillary block
	- Continuous cervical block
	- Continuous infraclavicular block
	- Continuous lumbar paravertebral block (CLPVB)
	- Continuous femoral nerve block
	- Continuous subgluteal sciatic block
	- combined saphenous and sciatic nerve block
	- Combined femoral and sciatic nerve block
Intravenous Regional Anesthesia (IVRA)	-Upper extremity
	- Lower extremity

## Knee surgery

Total knee arthroplasty (TKA) is a common procedure and it may cause significant pain in the acute postoperative period. Poor postoperative analgesia may effect mobilization, duration of discharge, patient satisfaction, morbidity and mortality. The studies evaluating the effects of regional anesthesia (RA) on functional outcome after TKA were conducted.<sup>35–39</sup> The results of some studies have suggested that Regional anesthesia seems to improve the outcome of patients undergoing total hip or knee replacement when compared with general anesthesia.<sup>36</sup> However, there are few data in the literature to support

## Femur neck fracture surgery

Some regional anesthetic techniques (for example low dose of spinal anesthesia, combined spinal epidural anesthesia have been used for femur fracture surgeries in some case reports.<sup>17–19</sup> Low dose of spinal anesthesia was successfully used in elderly and critically ill patients for open reduction of femur neck fracture.<sup>17</sup> In another article, Onal et al.<sup>18</sup> presented a case report with a geriatric patient at the age of 105 undergoing operation due to fracture in femur neck. They performed low dose of spinal anesthesia with 12.5mg izobaric bupivacain. They conclude that in geriatric patients, respiratory difficulty associated with the weakening of muscles, decrease in lung capacity, increased probability of postoperative atelectasia and aspiration due to decrease in reflexes makes general anesthesia risky. In view of this information and the comparison of advantages and disadvantages of general and regional techniques, and taking probable complications of geriatric population, it is our suggestion that regional techniques are more advantageous and safer than general anesthesia both in perioperative and postoperative period and that they may contribute to a decrease in morbidity and mortality rates.

Gupta et al.<sup>19</sup> presented an anesthetic management of a patient with dilated cardiomyopathy for fracture femur surgery under combined spinal epidural anesthesia (CSA). They reported that CSE using low-dose intrathecal bupivacaine and fentanyl with sequential epidural bupivacaine provided the advantages of spinal and epidural blockade, whilst avoiding some of their respective limitations. This sequential CSE technique may be particularly helpful in high risk cardiac disease patients in whom a slower onset sympathetic blockade is required. Thus, low-dose sequential CSE can be a safe alternate to achieve good anesthesia with impressive cardiovascular stability.

the hypothesis that regional anesthesia has any effect on functional outcome.<sup>37</sup>

Mulroy et al.<sup>38</sup> compared general, epidural, and spinal anesthesia for outpatient knee arthroscopy in a prospective, randomized clinical study. They compared discharge times, side effects, operating room (OR) efficiency, and patient satisfaction levels of three anesthetic techniques, each performed with an “ideal” drug, for outpatient arthroscopy in a prospective, randomized fashion. As a conclusion they reported that epidural anesthesia with chlorprocaine and general anesthesia with propofol-nitrous oxide provided equally effective

intraoperative conditions and PACU discharge times in our outpatient center. Spinal anesthesia with 75 mg of procaine with fentanyl in this setting was associated with an average of 42 to 54 minutes longer discharge times than the other two techniques, and a higher incidence of side effects. They suggested that further study will be needed to identify an appropriate spinal anesthetic that would produce discharge times equivalent to the results obtained with general or epidural anesthesia in this setting. Either general or epidural anesthesia provide satisfactory anesthesia for outpatient knee arthroscopy and the choice of anesthetic technique may be primarily dependent on the patient's desire to be alert and participatory during the surgical procedure. In another study, Korhonen et al.<sup>39</sup> compared selective spinal anesthesia (SSA) with bupivacaine and general anesthesia with desflurane for outpatient knee arthroscopy. The goal of this study was to assess whether SSA with small-dose hyperbaric bupivacaine provides an equal possibility of fast-tracking, a shorter stay in the postanesthesia care unit (PACU), and earlier discharge home compared with GA with desflurane. In conclusion, they reported that patients undergoing ambulatory knee arthroscopy had equal likelihood of meeting fast-track criteria and discharge times after SSA with 4mg of hyperbaric bupivacaine and after endotracheal GA with desflurane. However, those patients receiving SSA had lower pain scores and need of postoperative opioids, less PONV, and somnolence in the hospital.

Multimodal methods for controlling postoperative pain after knee surgery were introduced in the current clinical practice. Injections given locally into and around the joint, named as periarticular injections (PAI), intraoperatively have been extensively studied in knee arthroplasty patients.<sup>40-43</sup> Local anesthetic drugs like bupivacaine and opioids like tramadol and morphine were administered periarticular to provide postoperative analgesia in knee surgeries.<sup>41,44</sup> The results of a clinical study reported that intraoperative periarticular injection with multimodal drugs can significantly reduce the requirements for patient-controlled analgesia and improve patient satisfaction, with no apparent risks, following total knee arthroplasty.<sup>40</sup> Some authors compared with periarticular analgesic injections and peripheral nerve blocks like femoral nerve block (FNB) for postoperative analgesia after knee arthroplasty. They reported that multimodal periarticular soft tissue injection provided comparable analgesia to continuous FNB after total knee arthroplasty. They also concluded the analgesic effects of PAI and PNB are similar. And, PAI may be considered superior to PNB because it is easier to perform.<sup>42,43</sup>

In a recently article, Elmallah et al.<sup>45</sup> have reported that optimal pain control in patients undergoing total knee arthroplasty (TKA) is imperative for good rehabilitation and functional outcomes. Current modalities in use, such as patient-controlled analgesia, opioids, and epidural anesthetics, provide good pain relief but can be associated with side effects and serious complications. As a result, newer pain control modalities have been used to try to reduce the use of opioids while providing adequate pain relief. Currently, there are no clear guidelines or evidence for an optimum postoperative TKA analgesic regimen. They also have concluded that analgesics, such as newer oral medications, peripheral nerve blocks, and periarticular injections, may improve pain management, rehabilitation, and patient satisfaction, as well as reduce opioid consumption. The literature has also highlighted that a multimodal approach to pain management may provide the best results. However, determining which modalities provide superior pain control is still being extensively studied, and further research is needed.

### Foot and ankle surgery

Some types of lower extremity peripheral nerve blocks were

used for foot and ankle surgery. Lollo L & Stogicza A<sup>46</sup> compared the postoperative analgesic properties of combined femoral and sciatic nerve blockade with those of combined saphenous and sciatic nerve blockade in patients that underwent foot and ankle surgery. They reported that combined saphenous-sciatic nerve blockade was superior to femoral-sciatic nerve blockade for postoperative analgesia following foot and ankle surgery. And they also reported that combined popliteal sciatic and saphenous nerve blockade resulted in lower immediate postoperative pain scores in opioid naïve females and reduced immediate postoperative rescue opioid analgesic dosages in all patient groups.

### Conclusion

In a conclusion, the use of regional anesthesia techniques for postoperative outcomes in orthopedic surgeries has been investigated in lots of clinical studies and case reports. Most of the authors proposed that regional anesthesia in orthopedic patients may be associated with better postoperative pain control and a reduction in intraoperative blood loss when compared with general anesthesia. In the future regional anesthesia techniques will be more preferable anesthetic technique in orthopedic surgeries.

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### Conflicts of interest

The authors declare there is no conflict of interests.

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### References

1. Brinker MR, Reuben JD, Mull JR, et al. Comparison of general and epidural anesthesia in patients undergoing primary unilateral THR. *Orthopedics*. 1997;20(2):109-115.
2. Mauermann WJ, Shilling AM, Zuo Z. A comparison of neuraxial block versus general anesthesia for elective total hip replacement: A Meta-Analysis. *Anesth Analg*. 2006;103(4):1018-1025.
3. Macfarlane AJ, Prasad GA, Chan VW, et al. Does regional anaesthesia improve outcome after total hip arthroplasty? A systematic review. *Br J Anaesth*. 2009;103(3):335-345.
4. Eroglu A, Uzunlar H, Erciyes N. Comparison of hypotensive epidural anesthesia and hypotensive total intravenous anesthesia on intraoperative blood loss during total hip replacement. *J Clin Anesth*. 2005;17(6):420-425.
5. Jacop AK, Sviggum HP, Schroeder DR, et al. Perioperative nerve injury after THA regional anesthesia risk during a 20 years cohort study. *Anesthesiology*. 2011;115:1172-1178.
6. Casati A, Borghi B, Fanelli G, et al. Interscalene brachial plexus anesthesia and analgesia for open shoulder surgery: A randomized, double-blinded comparison between levobupivacaine and ropivacaine. *Anesth Analg*. 2003;96(1):253-259.
7. Eroglu A, Uzunlar H, Sener M, et al. A clinical comparison of equal concentration and volume of ropivacaine and bupivacaine for interscalene brachial plexus anesthesia and analgesia in shoulder surgery. *Reg Anesth Pain Med*. 2004;29(6):539-543.
8. Eroglu A. Patient-Controlled Analgesia after shoulder surgery. *Journal of Anesthesia & Critical Care: Open Access*. 2014;3(4).
9. Hadzic A, Arliss J, Kerimoglu B, et al. A comparison of infraclavicular nerve block versus general anesthesia for hand and wrist day-case surgeries. *Anesthesiology*. 2004;101(1):127-132.



10. Sen H, Kulahci Y, Bicerer E, et al. The analgesic effect of paracetamol when added to lidocaine for intravenous regional anesthesia. *Anesth Analg*. 2009;109(4):1327–1330.
11. Jankovic RJ, Visnjic MM, Milic DJ, et al. Does the addition of ketorolac and dexamethasone to lidocaine intravenous regional anesthesia improve postoperative analgesia and tourniquet tolerance for ambulatory hand surgery? *Minerva Anesthesiol*. 2008;74(10):521–527.
12. Akdogan A, Eroglu A. Comparison of the Effect of Lidocaine Adding Dexketoprofenand Paracetamol in Intravenous Regional Anesthesia. *BioMed Research International*. 2014.
13. Mauermann WJ, Shilling AM, Zuo Z. A comparison of neuraxial block versus general anesthesia for elective total hip replacement:A Meta-Analysis. *Anesth Analg*. 2006;103(4):1018–1025.
14. Macfarlane AJR, Prasad GA, Chan VWS, et al. Does regional anaesthesia improve outcome after total hip arthroplasty? A systematic review. *Br J Anaesth*. 2009;103(3):335–345.
15. Hu S, Zhang ZY, Hua YQ, et al. A comparison of regional and general anaesthesia for total replacement of the hip or knee:a meta-analysis. *J Bone Joint Surg Br*. 2009;91(7):935–942.
16. Choi S, Trang A, McCartney AC. Reporting functional outcome after knee arthroplasty and regional anesthesia. *Reg Anesth Pain Med*. 2013;38(4):340–349.
17. Al-Shraideh A. Low dose spinal anaesthesia in elderly & critically ill patients. *J Anesth Crit Care Open Access*. 2015;3(2):00099.
18. Onal O, Ozdemirkan A, Kutahya EC, et al. Our anesthesia experience with a 105 year old geriatric patient. *J Anesth Crit Care Open Access*. 2015;2(3):00054.
19. Gupta N, Garg R, Gupta A, et al. Anesthetic management of a patient with dilated cardiomyopathy for fracture femur surgery: a Case report. *J Anesth Crit Care Open Access*. 2015;2(1):00041.
20. Lollo L, Stogicza A. Combined saphenous–sciatic nerve blockade superior to femoral–sciatic nerve blockade for postoperative analgesia following foot and ankle surgery. *J Anesth Crit Care Open Access*. 2015;3(2):00095.
21. Borgeat A, Schappi B, Biasca N, et al. Patient-controlled analgesia after major shoulder surgery. PCIA versus PCA. *Anesthesiology*. 1997;87(6):1343–1347.
22. Borgeat B, Tewes E, Biasca N, et al. Patient-controlled interscalene analgesia with ropivacaine after major shoulder surgery:PCIA vs PCA. *Br J Anaesth*. 1998;81(4):603–605.
23. Borgeat A, Kalberer F, Jacob H, et al. Patient-controlled interscalene analgesia with ropivacaine 0.2% versus bupivacaine 0.15% after major open shoulder surgery:The effects on hand motor function. *Anesth Analg*. 2001;92(1):218–223.
24. Eroglu A. A comparison of patient-controlled subacromial and i.v. analgesia after open acromioplasty surgery. *Br J Anaesth*. 2006;96(4):497–501.
25. Memtsoudis SG, Sun X, Chiu YL, et al. Perioperative comparative effectiveness of anesthetic technique in orthopedic patients. *Anesthesiology*. 2013;118(5):1046–1058.
26. Sorenson EJ. Neurological injuries associated with regional anesthesia. *Reg Anesth Pain Med*. 2018;33(5):442–448.
27. Neal JM, Bernards CM, Hadzic A, et al. ASRA practice advisory on neurologic complications in regional anesthesia and pain medicine. *Reg Anesth Pain Med*. 2018;33:404–415.
28. Hogan QH. Pathophysiology of peripheral nerve injury during regional anesthesia. *Reg Anesth Pain Med*. 2008;33(5):435–441.
29. Welch MB, Brummett CM, Welch TD, et al. Perioperative peripheral nerve injuries:A retrospective study of 380,680 cases during a 10-year period at a single institution. *Anesthesiology*. 2009;111(3):490–497.
30. Auroy Y, Benhamou D, Bargues L, et al. Major complications of regional anesthesia in France:The SOS Regional Anesthesia Hotline Service. *Anesthesiology*. 2002;97(5):1274–1280.
31. Brull R, McCartney CJ, Chan VW, et al. Neurological complications after regional anesthesia:Contemporary estimates of risk. *Anesth Analg*. 2007;104(4):965–974.
32. Paul JE, Ling E, Lalonde C, et al. Deliberate hypotension in orthopedic surgery reduces blood loss and transfusion requirements:a meta-analysis of randomized controlled trials. *Can J Anesth*. 2007;54(10):799–810.
33. Jacop AK, Mantilla CB, Sviggum HP, et al. Perioperative nerve injury after THA regional anesthesia risk during a 20 years cohort study. *Anesthesiology*. 2011;115(6):1172–1178.
34. Ansari F, Misra S. Post-operative continuous epidural infusion in geriatric patients with cardiopulmonary co-morbidities:comparison between ropivacaine and levobupivacaine. *J Anesth Crit Care Open Access*. 2015;3(3):00101.
35. Koşucu M, Coşkun I, Eroglu A, et al. The effects of spinal, inhalation, and total intravenous anesthetic techniques on ischemia–reperfusion injury in arthroscopic knee surgery. *Biomed Res Int*. 2014:846570.
36. Hu S, Zhang ZY, Hua YQ, et al. A comparison of regional and general anaesthesia for total replacement of the hip or knee:a meta-analysis. *J Bone Joint Surg Br*. 2009;91(7):935–942.
37. Choi S, Trang A, McCartney AC. Reporting functional outcome after knee arthroplasty and regional anesthesia. *Reg Anesth Pain Med*. 2013;38(4):340–349.
38. Mulroy MF, Larkin KL, Hodgson PS, et al. A comparison of spinal, epidural, and general anesthesia for outpatient knee arthroscopy. *Anesth Analg*. 2000;91(4):860–864.
39. Korhonen AM, Valanne JV, Jokela RM, et al. A Comparison of selective spinal anesthesia with hyperbaric bupivacaine and general anesthesia with desflurane for outpatient knee arthroscopy. *Anesth Analg*. 2004;99(6):1668–1673.
40. Busch CA, Shore BJ, Bhandari R, et al. Efficacy of periarticular multimodal drug injection in total knee arthroplasty. A randomized trial. *J Bone Joint Surg Am*. 2006;88(5):959–963.
41. Eroglu A, Saracoglu S, Erturk E, et al. A comparison of intraarticular morphine and bupivacaine for pain control and outpatient status after an arthroscopic knee surgery under a low dose of spinal anaesthesia. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(11):1487–1495.
42. Uesugi K, Kitano N, Kikuchi T, et al. Comparison of peripheral nerve block with peri articular injection analgesia after total knee arthroplasty:a randomized, controlled study. *Knee*. 2014;21(4):848–852.
43. Ng FY, Ng JK, Chiu KY, et al. Multimodal periarticular injection vs continuous femoral nerve block after total knee arthroplasty:a prospective, crossover, randomized clinical trial. *J Arthroplasty*. 2012;27(6):1234–1238.
44. Beyzadeoglu T, Yilmaz C, Bekler H, et al. Intraarticular tramadol plus pericapsular incisional bupivacaine provides better analgesia than intraarticular plus pericapsular incisional bupivacaine after outpatient arthroscopic partial meniscectomy. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(5):564–568.
45. Elmallah RK, Cherian JJ, Pierce TP, et al. New and common perioperative pain management techniques in total knee arthroplasty. *J Knee Surg*. 2015;29(2):169–178.
46. Lollo L, Stogicza A. Combined Saphenous–Sciatic Nerve Blockade Superior to Femoral–Sciatic Nerve Blockade for Postoperative Analgesia Following Foot and Ankle Surgery. *J Anesth Crit Care Open Access*. 2015;3(2):00095.