PERIPHERAL NERVE BLOCK VERSUS SPINAL ANESTHESIA FOR TOTAL KNEE REPLACEMENT IN ELDERLY PATIENTS

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ABSTRACT

Spinal anesthesia and peripheral nerve block anesthesia are used in total knee replacement. The aim of the study was to examine whether peripheral nerve block anesthesia would provide a more stable hemodynamic profile and analgesic effect in elderly patients undergoing total knee replacement, as compared to spinal anesthesia. This is a single-center case-control trial, with patients from our prospectively followed registry. The patients were divided into two groups, those with peripheral nerve block anesthesia and spinal anesthesia. Propensity score analysis was performed in 1:1 ratio. The primary outcome was analgesia with total analgesic effect and the secondary outcome was intraoperative hemodynamic status. The patients in peripheral nerve block anesthesia group had a longer length of analgesia (606.19±219.35 vs 359.48±106.82, P<0.01) and pain scores during 24h and 48h after the surgery were lower in the same group of patients (3.21±1.74 vs 5.02±2.23, P=0.037; 3.03±1.57 vs 5.67±2.51, P=0.028). Spinal anesthesia group had a larger number of patients with significant hypotension (3.84% vs 15.38%, P=0.01), as well as a larger number of patients who received vasopressors (0% vs 9.61%, P<0.01). Both anesthesia methods demonstrated sufficient analgesic efficacy in total knee replacement, although there was less pain severity and longer analgesic effect of peripheral nerve block anesthesia in patients who were 60 years old or older. Spinal anesthesia showed a significantly higher degree of hypotension than in those patients receivingperipheral nerve block anesthesia.

Keywords: *Total knee replacement, spinal anesthesia, peripheral nerve block anesthesia.*

INTRODUCTION

Total knee replacement (TKR) remains the most effective treatment of the end-stage osteoarthrosis. It is most frequently performed among older patients, where sensitivity to the different type of drugs applied during anesthesia is higher, thus resulting in more frequent hemodynamic instability.

TKR may be performed under both general and regional anesthesia. The ability to provide superior postoperative analgesia, rapid postoperative rehabilitation and reduced cost of medical care may have resulted from thoughtfully implemented regional anesthetic and analgesic techniques. Also, recent studies have shown that in patients undergoing regional anesthesia, there was a significantly lower level of stress hormones and more rarely postoperative cognitive dysfunction in comparison to general anesthesia (GA) (1,2). Because of this, the use of regional anesthesia, including spinal, epidural, and peripheral block has increased.

Peripheral nerve block (PNB) carries potential advantages such as hemodynamic stability and better postoperative pain control (3,4). PNB is reported to provide effective analgesia, facilitate physical therapy, and reduce length of hospital stay compared to other regional anesthetic techniques (5,6). In our institution, TKR surgery is commonly done under spinal anesthesia (SA) or PNB. Therefore, the main aim of the study was to examine whether PNB would provide a more stable hemodynamic profile and postoperative pain scores in elderly patients undergoing TKR surgery, as compared to SA.

MATERIALS AND METHODS

Study design and patient population

The study was designed as single-center case-control trial, with patients from our prospectively followed registry. Between January 1st 2013 and January 1st 2015, the total number of consecutive 895 TKRs was done at the Institute for Orthopedic Surgery „Banjica“. Out of these, 104 (11.62%) were done in PNB, 52 (5.81%) in GA and 739 (82.56%) in SA. Those operated in PNB and SA were recruited for this study (Figure 1). The study protocol was approved by the Ethics Committee of the institution and was conducted according to the principles of the Declaration of Helsinki. Informed consent was obtained from all patients.

The inclusion criteria were the patients: older than 60 years, undergoing elective single TKR surgery; who had met the American Society of Anesthesiologists physical (ASA) status I -III and that had no allergy to local anesthetics.

The exclusion criteria were: contraindications for PNB and SA (coagulation defects, infection at the puncture site), bone degenerative disease and posttraumatic condition of the spine, current severe psychiatric disease, alcoholism or drug dependence, no dementia (Mini-Mental Score Examination > 23) and severe visual or auditory disorder.

The data were collected about demographics (age, body mass index and sex), baseline comorbidities (smoking status, presence of hypertension, hyperlipidemia and diabetes mellitus), ASA score, the intraoperative data (time of anesthesia induction, length of surgery, leg/side being operated, total anesthesia time - defined as the time from anesthesia induction until the end of surgery, the total amount of fluid expressed in milliliters, the administration of either coloid solutions or blood transfusion, blood loss, the use of vasopressors and opioids and the episode of significant hypotension defined as a drop of more than 30% of systolic blood pressure during the operation compared to the baseline values. Also, the intraoperative data reflecting the hemodynamic status (systolic - SBP and mean blood pressure - MAP, as well as the heart rate - HR) were collected every 5 minutes during the first 30 minutes, and then every 10 minutes until the end of surgery. Postoperative characteristics (length of analgesia defined as the time from anesthesia induction untilthe first reappearance of pain which necessitated the administration of opioids and length of hospital stay) as well as the average numerical pain score (NPS) rating (numeric score 0-10; 0 without pain, 1-3 mild, 4-6 moderate and >7 strong pain) for the first three postoperative days were collected.

The patients were divided into two groups, those with PNB anesthesia and those with SA. All patients who underwent PNB met the inclusion criteria. The propensity score analysis was performed by matching PNB group of patients to SA patients controlling the demographics, baseline comorbidities and ASA vaules in 1:1 ratio (Figure 1).

Regional anesthesia techniques

Since all patients underwent TKR at the same hospital, regional anesthesia techniques were completely standardized. All patients received 500 ml of intravenous cristaloids prior to anesthesia. For sedation, the patients received Midazolam (0.07-0.1 mg/kg) intramuscularly. Standardized monitoring, such as non-invasive blood pressure (BP), heart rate (HR), electrocardiography and pulse oximetry, was conducted. To measure BP, a BP cuff was fitted to the patient's upper arm and BP was measured in the patient in the supine position.

The patients in PNB group had lumbar plexus, sciatic and femoral nerve blocks done with a nerve stimulator (STIMUPLEX®S,B BRAUN,Germany). After the sterile preparation and draping, the nerve blocks were administered using a 21 gauge needle (Stimuplex®A, Insulated Needle, 21G × 4“,0.80 ×100mm, B BRAUN, Germany). Posterior approach to lumbar plexus block (LPB) was performed in patients in the lateral decubitus position. The puncture site was at the level of intercristal line 3 cm caudal and 5 cm lateral midline to the spinous processes. Sagittal insertion direction

was used. The puncture depth was typically 6 -10 cm. After the insertion of the needle in the psoas space, a sign of the lumbosacral plexus identification muscle activity (with the nerve stimulator settings at 2 Hz frequency and current at 0.3 -0.5 mA) from the quadriceps muscle was noted. After the negative aspiration test, 10-15 ml of 1,3% lidocaine and 10-15 ml of 0,25% bupivacaine were injected. The aspiration test was repeated on every 3-4 ml of a given anesthetic.

Sciatic nerve block (SNB) was performed in the same position. The puncture site was at the middle of the line connecting posterior superior illiac spine and greater trochanter and 5cm caudal (Labat line). After the field preparation, the needle was inserted at 6-8 cm depth below the skin puncture, and both plantar and dorsal flexation of the foot was elicited as a reaction from tibial and peroneal part of the ischiadic nerve. Again, after the negative aspiration test, 3-4 ml anesthetic (1,3% lidocaine and 0,25% bupivacaine) was injected intermittently with a constant repetition of the aspiration test, until the total dose of 10 ml 1.3% lidocaine and 10-15 ml 0.25% bupivacaine.

The supine approach was used for femoral nerve block (FNB). The leg position was in a slight abduction. The femoral artery pulse was palpated 1-2 cm below the inguinal ligament. The punction site was 1-1.5 cm laterally from the artery and the femoral nerve was indentified 2-3cm below the skin level. With a similair current, a 10 mL of of 1,3% lidocaine and 10-15 ml of 0,25% bupivacaine were injected.

The puncture site for the patients in SA was at the L3 or L4 level with a 25 gauge spinal needle (Spinocan, 25G, B Braun, Germany) in the patient in the sitting or lateral decubitus position, under the aseptic technique. With perpendicular position of the needle and avoidance of moving the needle, 2 ml of 2% lidocaine and 3 ml of 0,5% bipuvacaine were administered. Following the administration of SA or PNB, the patients were placed in the supine position for a surgery.

The patients who developed hypotension were given intravenous ephedrine in titrated boluses, then resuscitated with intravenous fluids as needed. After the operation, all patients were prescribed intravenous Paracetamol (acetaminofen), nonsteroidal anti-inflamatory drugs or opioids (Tramadol) if needed, when the average NPS was six or higher. The patients were followed up on the wards later in order to determine pain-free duration and pain scores in the first three postoperative days.

Statistical analysis and outcomes

Continuous variables were presented as mean±standard deviation. Group comparisons were performed using the Student t-test or ManneWhitney U test, as appropriate. Categorical data were expressed as percentages and were compared using the chi-square test or Fisher exact test. Differences were considered statistically significant at $p < 0.05$. Differences between curves were tested using the log-rank test. Analyses were done with SPSS software, version 20.0 (SPSS, Chicago, IL, USA).

The primary outcome was analgesia assessed by: duration of analgesia (expressed as the time from anesthesia induction until the reappearance of pain necessitating the administration of opioids) and postoperative numeric pain scores until the fourth postoperative day. The secondary outcomes were intraoperative hemodynamic status, as well as the use of vasopressor drugs and the appearance of signficant hypotension as defined above.

RESULTS

Demographic and baseline characteristics

The demographic data and baseline clinical characteristics are shown in Table 1. There were no significant differences between the groups in terms of these data. The intraoperative variables are shown in Table 2. The anesthetic induction time of PNBs was longer (22.03±9.31 vs 7.89±2.87 minutes, P<0.01), as well as the total anesthesia time (160.17±40.92 vs 145.96±37.71, P<0.01), although it did not change the total operative time (115.02±28.17 vs 113.54±36.46 minutes, P=0.77). The overall administration of fluids during the operation (1834.62±617.43 vs 1040.38±421.85 ml, P<0.01), as well as the total number of patients that received coloid solutions (41.34% vs 3.84%, P<0.01) and opioids (8.65% vs 0%, P<0.01) were higher in SA group.

Hemodynamic variables

The hemodynamic variables are shown in Table 3 and Figures 2, 3, 4, 5. We compared changes in the hemodynamic variables during the surgery in SA and PNB groups. Compared with the patients in PNB group, the patients in SA group had an overall lower SBP (114.38±13.30 vs 130.87±14.83 mmHg; P<0.01) and MAP (84.61±9.47 vs 96.15±10.63, P=0.015). There was no difference in the mean heart rate (78.23±10.07 vs 80.69±12.18, P=0.41) throughout most of the observation period after induction of anesthesia. Compared to PNB group, SA group had a considerably larger number of the patients with significant hypotension (3.84% vs 15.38%, P=0.028), as well as a larger number of the patients who received vasopressors (0% vs 9.61%, P=0.019) (Table 4).

Analgesic efficacy

All patients received opioids postoperatively. The patients in PNB group had a statistically significant longer length of analgesia (606.19±219.35 vs 359.48±106.82, P<0.01). Pain scores during 24h and 48h after the surgery were lower in PNB patients (3.21±1.74 vs 5.02±2.23, P=0.037; 3.03±1.57 vs 5.67±2.51, P=0.028), but there was not a statistically significant difference in the same pain scores during 72h and 96h respectively (2.57±1.05 vs 4.21±1.82, P=0.094; 2.08±0.88 vs 2.83±1.69, P=0.43) (*Table 5,* Figure 5). The patients receiving PNB as an anesthetic technique had a significantly shorter intrahospital stay (7.81±2.68 vs 8.77±3.66, P=0.03) (Table 2).

Table 1. Baseline clinical characteristics

Characteristics	PNB* (n=104)	SA* (n=104)	p value
Demographics			
Age	67.96±6.10	68.98±6.51	0.24
Body mass index	25.64±3.10	26.16±3.15	0.23
Female	74 (71.15%)	68 (65.38%)	0.67
Risk factors			
Smoker	43 (41.34%)	41 (39.42%)	0.88
Hypertension	64 (61.53%)	66 (63.46%)	0.86
Hyperlipidemia	17 (16.34%)	15 (14.42%)	0.84
Diabetes mellitus	8 (7.69%)	7 (6.73%)	1.00
*ASA score**			
I	33 (31.73%)	33 (31.73%)	1.00
II	64 (45.71%)	62 (59.61%)	0.88
III	8 (7.66%)	9 (8.66%)	1.00

ASA score* - American Society of Anaesthesiologists score, PNB* - peripheral nerve block, SA* - spinal anesthesia

Table 2. Intra- and postoperative characteristics

Characteristics	PNB* (n=104)	SA* (n=104)	p value
Intraoperative data			
Anesthetic induction time, minutes	22.03±9.31	7.89±2.87	**<0.01**
Length of surgery	115.02±28.17	113.54±36.46	0.77
Side of surgery, right/left	59/45	64/40	0.57
Anesthesia time, minutes	160.17±40.92	145.96±37.71	**0.01**
Fluid administration, ml	1040.38±421.85	1834.62±617.43	**<0.01**
Coloid solutions	4 (3.84%)	43 (41.34%)	**<0.01**
Blood loss, ml	300.05±716.11	311.54±322.11	0.88
Blood transfusion	4 (3.84%)	6 (5.76%)	0.74
Opioids	0 (0%)	9 (8.65%)	**<0.01**
Postoperative data			
Intrahospital stay, days	7.81±2.68	8.77±3.66	**0.03**

PNB* - peripheral nerve block, SA* - spinal anesthesia

Table 3. Intraoperative hemodynamic status

Hemodynamic variable	Groups	Baseline value	End of surgery	p value
SBP* (mmHg)	PNBA	145.21±10.56	125.58±17.61	**<0.01**
	SA	148.37±25.78	122.45±19.25	
MAP* (mmHg)	PNBA	105.08±8.11	94.59±11.23	**<0.01**
	SA	101.67±7.41	88.19±10.78	
Heart rate (beats/minute)	PNBA	79.56±10.87	81.77±13.04	0.58
	SA	82.15±13.04	78.18±10.95	0.37

PNBA* - peripheral nerve block anesthesia, SA* - spinal anesthesia, SBP* - systolic blood pressure, MAP* - mean arterial pressure

Table 4. Comparison between PNB and SA group with significant hypotension and need for vasopressors

Characteristics	PNBA* (n=104)	SA* (n=104)	p value
Significant hypotension*	4 (3.84%)	16 (15.38%)	**0.028**
Need for vasopressors	0 (0%)	10 (9.61%)	**0.019**

*Significant hypotension is defined as a drop of >30mmHg from baseline systolic blood pressure
PNBA* - peripheral nerve block aneshesia, SA* - spinal anesthesia

Table 5. Pain analysis

Hemodynamic variable	PNBA* (n=104)	SA* (n=104)	p value
Length of analgesia, minutes	606.19±219.35	359.48±106.82	**<0.01**
Pain scores 24h after the surgery	3.21±1.74	5.02±2.23	**0.037**
Pain scores 48h after the surgery	3.03±1.57	5.67±2.51	**0.028**
Pain scores 72h after the surgery	2.57±1.05	4.21±1.82	0.094
Pain scores 96h after the surgery	2.08±0.88	2.83±1.69	0.43

PNBA* - peripheral nerve block anesthesia, SA* - spinal anesthesia

Figure 1. Flow chart diagram showing patient enrollment

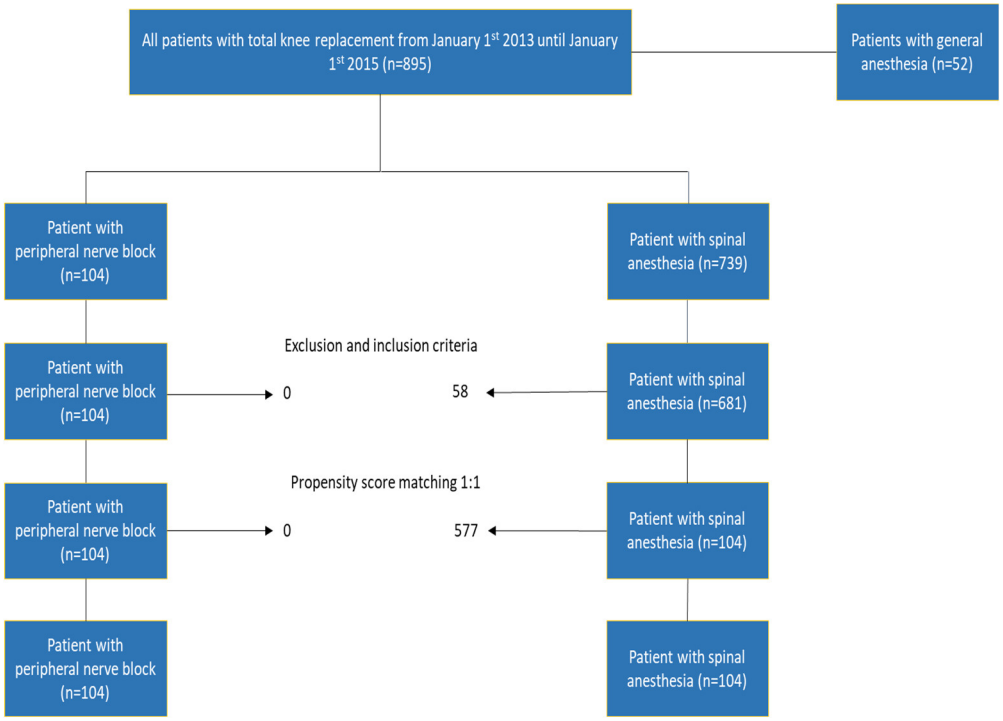


Figure 2. Systolic blood pressure (SBP) for SA group and PNB group every 5 minutes during the first 30 minutes and then every 10 minutes until the end of surgery. Data are presented as the mean ± standard deviation (SD).

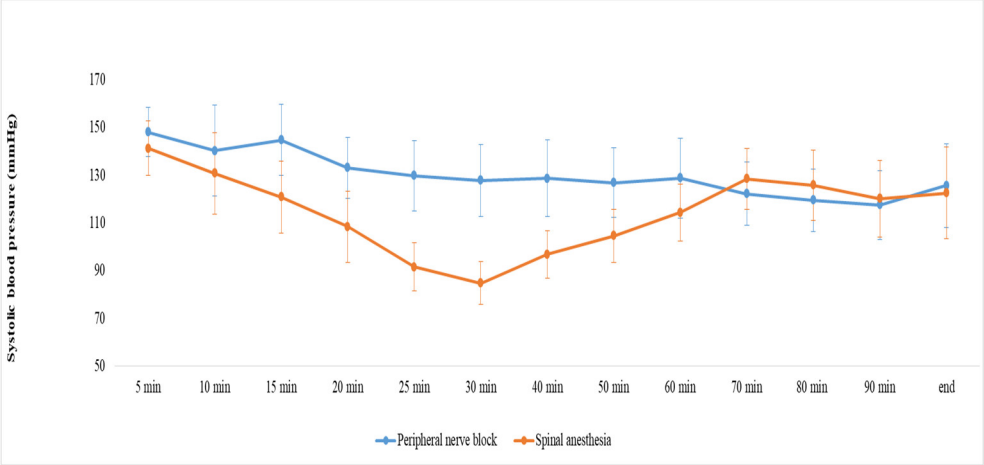


Figure 3. Mean arterial pressure (MAP) for SA group and PNB group every 5 minutes during the first 30 minutes and then every 10 minutes until the end of surgery. Data are presented as the mean ± standard deviation (SD).

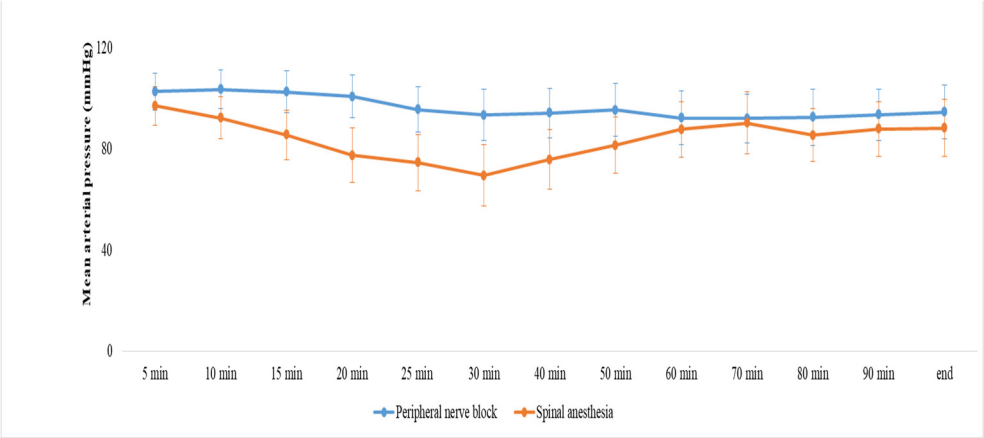


Figure 4. Heart rate (HR) for SA group and PNB group every 5 minutes during the first 30 minutes and then every 10 minutes until the end of surgery. Data are presented as the mean ± standard deviation (SD).

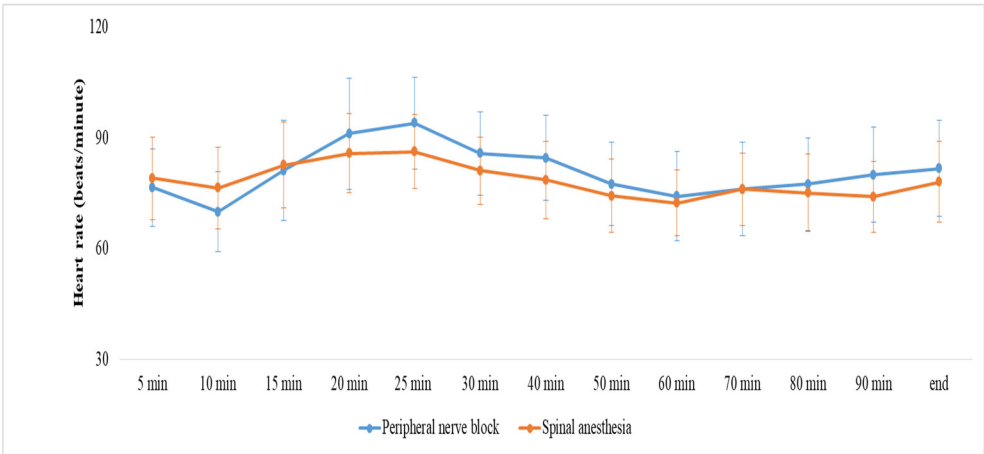
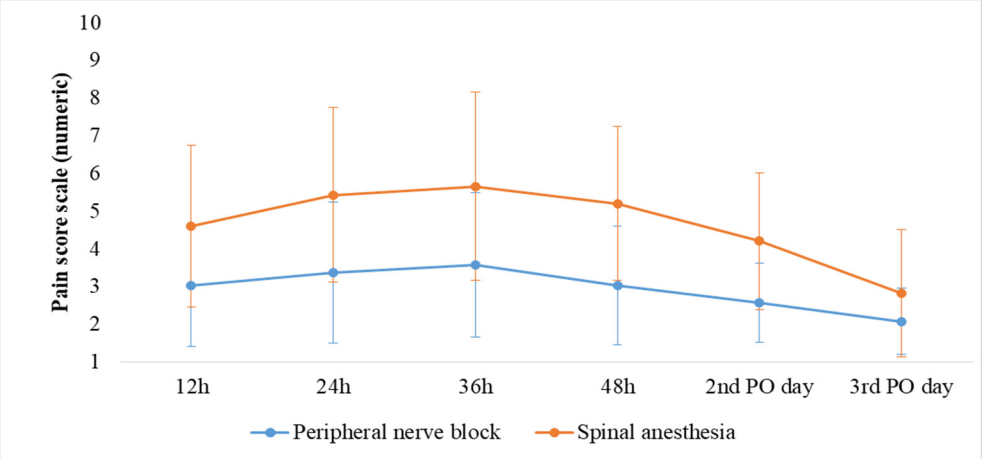


Figure 5. Pain scale for SA group and PNB group at six distinct points: 12h, 24h, 36h, 48h, the second and third postoperative day. Data are presented as the mean ± standard deviation (SD).



*PO - postoperative

DISCUSSION

In this study, we found that the patients that were given PNB had longer analgesia time. Pain scores were lower during the first 48h after the operation, but after that time, this difference was not significant. The patients that received SA had significant and prolonged hypotension more often that was treated with fluids and vasopressors as necessary in comparison to those receiving PNB.

It has been reported that most of the analgesic benefit of PNB seems to occur during the early postoperative period after TKA, with very little effect extending beyond 48 hours (6,7). Good postoperative pain control has been reported to accelerate rehabilitation (6). Our data were in accordance to these findings. We have also found a significant difference between the patients in the treatment groups with regard to the time of the first request for opioids. The patients receiving PNB consistently reported lower pain scores, faster discharge from hospital, and lower opioid consumption (8-10).

Peripheral block anesthesia for knees has traditionally involved the use of a femoral nerve block (FNB), either in isolation or in conjunction with a sciatic nerve block (SNB). This combined femoral and sciatic block has been shown to provide superior pain relief over an isolated FNB alone as SNB provides posterior analgesia that FNB cannot provide (11). While perhaps not beneficial in isolation, they may aid to improve pain control as part of the so-called three-in-one nerve block (12). Nonetheless, SA is associated with more complete, denser surgical block and thus less chance of a patchy block resulting in pain during surgery, compared to other forms of regional anesthesia.

The use of regional anesthesia is common in our institution. In our hands, the technique was effective for providing surgical anesthesia. Athough considered quite safe, all used techniques should be repeatedly evaluated for any associated risks. There is always a debate about the risk/benefit ratio of using the regional anesthesia. When considering the risk profiles associated with each of the two methods used here, there are some recognized differences. As previously mentioned, SA offers rapid onset analgesia with minimal systemic toxicity and prolonged duration in the postoperative period (13). However, SA intraoperatively provides more cardiovascular instability and sudden cardiac death may happen, especially among elderly and diabetic patients with autonomic neuropathy, due to impaired compensation to the vasodilatory effects of anesthesia (14). Even if these complications are considered to be rare, severe ones such as headache, cauda equina syndrome and risk of infection have also been reported for spinal anesthesia (15). On the other side, PNBs are not without disadvantages. These include motor inhibition and the potential risk of falls as a result of quadriceps weakness (16,17). Furthermore, there is a small but significant risk of neurologic and vascular compromise as a result of the procedure (18). While neurologic symptoms are usually limited to nerve dysesthesias that are resolved within weeks or months, more significant nerve injuries are possible (17). Also, a negative effect such as an uncomfortable position of the patient in both PNBA and SA should be acknowledged when compared to general anesthesia.

We observed a significant drop in blood pressure in 15.38% of patients in SA and 3.84% in PNB group and on the other side, the use of vasopressores was also more common in the same groups (9.61% vs 0%). Hypotension can result in cardiac ischaemia, cerebral hypoperfusion, acute tubular necrosis and renal injury. A study by Monk et al. showed that intraoperative hypotension is associated with an increased 30-day operative mortality (19). Therefore, intraoperative hypotension is undesirable. PNBs have been shown to result in more stable hemodynamics as compared to general anesthesia (20) and neuraxial block (21).

Therefore, significant hemodynamic changes would lead in some high risk patients, such as dose in ASA score 3 to exarcebation of their cardiovascular status and potentially fatal outcomes. With these results, our study showed that PNB resulted in stable BP and HR, and would, therefore, be a good choice of anesthesia for patients undergoing TKR.

It is also interesting to see a combination and concentration of different local anesthetics used in a different center for both PNB and SA. In comparison to other studies, (22-24)we used maximally 45 ml 0.25% bupivacaine and 35ml 1.3% lidocaine for lumbar plexus, sciatic and femoral block altogether. For SA, we used a combination of 2 ml 2% lidocaine and 3 ml 0.5% bupivacaine. Although the volume of local anesthetics used in our center is higher, the concentration is significantly lower, which reduces the possibility of systemic adverse events. These authors found similarly that PNB provided more stabile hemodynamic effect during the surgery, longer sensory blockade and lower postoperative pain scores (22-24).

While both periarticular injections and PNBs provide superior pain relief when compared to narcotic use alone, they appear to provide similar pain relief postoperatively. Recent meta-analysis of 10 randomized, controlled trials that included the total number of 744 total knee arthroplasties comparing PNBs to periarticular injections found similar results in regard to the pain control and postoperative function (25). Hannon et al. in their recent survey about current analgesia and anesthesia practices in USA containing 28 questions have found that there was no consensus regarding the optimal multimodal anesthetic and analgesic regimen for TKR (26). In our research, all patients received intravenous infusion of Paracetamol 12 hours after the surgery and 100 mg of Trodon, if the average numeric pain score was six or higher.

Perineural continuous infusion catheters have been both used in knee arthroplasty. The results from 2 recent meta-analyses suggest that continuous intra-articular infusion catheters may improve the short-term pain control following total knee arthroplasty, but given the heterogeneity of studies, both studies were unable to offer any firm conclusions (27,28). Prolonged perineural continuous infusion catheters (the so-called continuous blocks) may offer extended pain relief and more rapid progression of function following surgery when compared to placebo (29) and shorter-term infusion catheters (30,31). However, when compared to a single-injection neural blockade or even periarticular injection alone, several randomized, controlled trials have demonstrated no benefit in using the infusion catheter (32-34).

The discussion is ongoing concerning the possible benefits of ultrasound-guided peripheral nerve blocks compared to blocks performed with the use of a nerve stimulator, particularly with respect to the analgesic quality. However, although some studies have shown a trend toward a possibly better outcome when blocks are performed under the ultrasound guidance, no study has shown yet a significant benefit when compared to the nerve stimulator-guided techniques (35). In our study, all blocks were performed by a highly experienced anesthesiologist.

Limitations and strengths of the study

The study has several limitations. First, it was a single centre study. Second, although spinal anesthesia resulted in hypotension, it is not known if this led to a higher rate of cardiac adverse events after the hospital discharge. Only the increased length of hospital stay was noted among these patients. The main strength of this study is a large number of patients with a detailed clinical information, which provides statistical power to make comparisons among groups and valid conclusions.

CONCLUSION

In conclusion, both anesthesia methods demonstrated sufficient analgesic efficacy in TKR, although there was less pain severity and longer analgesic effect of PNB in patients who were 60 years old or older. SA showed a significantly higher degree of hypotension than in those receiving PNB. PNB provided a hemodynamic stability and therefore should be considered, whenever possible, as an option of anesthesia for TKR. Continued research is warranted to determine the most optimal anesthesia in terms of analgesia and hemodynamics following TKR.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Ethics Committee of the institution and was conducted according to the principles of the Declaration of Helsinki. Informed consent was obtained from all patients

CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

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None.

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