Open Journal of Anesthesiology, 2017, 7, 88-97
http://www.scirp.org/journal/ojanes
ISSN Online: 2164-5558
ISSN Print: 2164-5531

The Effect of Different Regional Blocks: Combined Femoral-Sciatic, Spinal and Epidural Blocks on the Different Side Effects of Arterial Tourniquet in Patients Undergoing Lower Limb Orthopedic Surgeries

—A Randomized Controlled Trail

Heba Omar*, Bassant Abd Elhamid, Ashraf Rady, Shaymaa Khaled

Faculty of Medicine, Cairo University, Cairo, Egypt
Email: *hebaomar2@yahoo.com, bassantmohamed197@yahoo.com, arady_60@hotmail.com, shaymaakhaled188@outlook.com

How to cite this paper: Omar, H., Elhamid, B.A., Rady, A. and Khaled, S. (2017) The Effect of Different Regional Blocks: Combined Femoral-Sciatic, Spinal and Epidural Blocks on the Different Side Effects of Arterial Tourniquet in Patients Undergoing Lower Limb Orthopedic Surgeries. *Open Journal of Anesthesiology*, **7**, 88-97.
https://doi.org/10.4236/ojanes.2017.74009

Received: March 20, 2017
Accepted: April 25, 2017
Published: April 28, 2017

Abstract

Background: Pneumatic arterial tourniquet is a very commonly used technique in limb surgeries to provide bloodless field to facilitate dissection and decrease blood loss. However, arterial tourniquet has many deleterious effects including hemodynamic changes, serum lactate and potassium level changes and tourniquet-induced pain which sometimes can be severe and intolerable. **Aim of the study:** To evaluate the effect of different regional blocks: femoral-sciatic, spinal and epidural blocks on serum lactate and potassium levels and the degree of arterial tourniquet-induced pain in patients undergoing lower limb orthopedic surgeries. **Methods:** 60 patients underwent lower limb orthopedic surgery with application of tourniquet for duration not more than 90 minutes. Patients were assigned randomly to one of three groups (20 each) Group I had sciatic-femoral block, Group II: patients had spinal anesthesia and Group III: patients had epidural anesthesia. Intraoperative hemodynamics, changes in serum potassium and lactate levels and tourniquet pain after tourniquet inflation & deflation, were recorded. **Results:** There was no statistically significant difference among the three groups regarding tourniquet pain after tourniquet inflation (**p = 0.872**) and deflation (**p = 0.902**), and regarding serum levels changes of potassium (**p = 0.067**) and lactate (**p = 0.051**). However, each group showed statistically significant increase in post deflation tourniquet pain (**p = 0.003, 0.002, 0.003, in groups F, S, E respectively**) and serum potassium (**p = 0.004, 0.006, 0.000, in groups F, S, E respectively**) and lactate levels (**p = 0.004, 0.000, 0.000, in groups F, S, E respectively**) when compared to the pre-deflation values, and the increase was directly proportional to the duration of tourniquet. **Conclusion:** the three different types of anesthesia (femoral- sciatic, spinal and epidural block) have the same effect on serum lactate and potassium levels and the degree of tourniquet pain, which were related to the duration of tourniquet inflation.

Keywords

Tourniquet Pain, Potassium, Lactate, Femoral-Sciatic, Spinal, Epidural

1. Introduction

Pneumatic tourniquets are widely used in limb surgeries to provide a bloodless field and to facilitate surgical dissection. However, it is important to appreciate their potential complications, e.g., tourniquet pain, limb ischemia, nerve injury and reperfusion injury, which may be minimized by understanding the proper technique of tourniquet, careful patient evaluation to exclude contraindications and by using modern pneumatic tourniquets which are designed to minimize the incidence of these potential complications [1].

Tourniquet usage is involved with metabolic changes and reperfusion injuries that related to the tourniquet phase [inflation (ischemia) & deflation (reperfusion)], the duration of tourniquet inflation, and the anesthetic technique [2]. Application and release of the extremity tourniquet causes anaerobic metabolism and several metabolic changes resulting in acidosis with hypoxemia, hypercapnia, hyperkalaemia and formation of free radicals [3].

Tourniquet pain is one of the complications that is very disturbing to patient, surgeon & anesthetist, which sometimes necessitates conversion to general anesthesia, as tourniquet pain can complicate spinal or epidural anaesthesia, despite apparently adequate anaesthesia of the sensory dermatome underlying the tourniquet [4]. After tourniquet inflation, patients usually experience a vague, dull pain in the limb, which is thought to be via cutaneous neural mechanism. The average pain tolerance duration is 31 min [5] which can be increased to 45 min with sedation [6]. It's found that the tourniquet pain incidence is more common in lower limb surgery and associated with increasing patient age and the surgery duration [7]. Many theories state that tourniquet pain is predominantly mediated by unmyelinated, slowly conducting C-fibres which are affected to a less extent by the compression of tourniquet inflation than larger fibres [8].

This randomized control study (RCT) was designed to assess the effect of different regional anesthetic techniques; combined femoral-sciatic block, spinal block & epidural block, on arterial tourniquet consequences. The primary outcome variables were 1) metabolic changes (serum potassium & lactate levels changes after tourniquet deflation), 2) degree of pain induced by arterial tourniquet inflation under the effects of these three different regional blocks. The secondary outcome variables were intraoperative hemodynamic changes (blood pressure and heart rate) during applying arterial tourniquet.

Aim of the Study

This study is to evaluate the effect of different regional blocks: femor-sciatic, spinal and epidural blocks on the arterial tourniquet-induced metabolic chnges and pain in patients undergoing lower limb orthopedic surgeries.

2. Patients and Methods

After approval of the Ethics Committee of Kasr El-Aini Hospital, Faculty of Medicine, Cairo University and obtaining informed written consent from each patient, this prospective randomized study was conducted at Kasr El-Aini Hospital from May 2015 till September 2015, on sixty patients scheduled for different lower limb surgeries using arterial tourniquet were enrolled in this study. **Included patients** were those aged between 20 - 60 years old and classified by the American Society of Anesthesiologist (ASA) physical status as class I or class II, and Maximum tourniquet time was 90 minutes. **Exclusion criteria** were patients' refusal of regional block, history of allergic reactions to local anesthetics, coagulopathy and severe cardiac, respiratory, hepatic or renal disease.

On arrival to the operating room, the patient was attached to routine monitors *i.e.* electrocardiogram (ECG), pulse oximetry & non-invasive blood pressure monitor was applied and set to measure blood pressure every 5 minutes . 18 G IV cannula was inserted; all patients received intravenous (IV) premedication with 0.03 mg/kg of midazolam, followed by a 10 mL/kg infusion of lactated Ringer's solution.

Then, 60 patients were randomly allocated using computerized generated random tables and the random numbers were concealed in closed opaque envelope into 3 groups (20 patients in each group):

Group F: patients had **combined femoral and sciatic block** using a mixture of 20 mL of lidocaine 2% plus 20 mL of bupivacaine 0.5%. (20 ml of the mixture was injected in each block) with the aid of nerve stimulator connected to a 21-gauge 100-mm Stimuplex block needle (B. Braun Medical Inc, Melsungen, Germany). Stimulation frequency was set at two Hz, whereas the intensity of the stimulating current was 0.3 to 0.5 mA.

Group S: patients had **spinal anesthesia**, dural puncture was performed at interspace L3-L4 with a 29 gauge spinal needle after infiltration of the skin at the site of lumbar puncture with 2 cm of lidocaine 1%., then 2.5 ml of 0.5% heavy bupivacaine are injected intrathecally

Group E: patients had **epidural anesthesia,** as epidural catheter was inserted in the sitting position at the level of L3-L4 intervertebral space, using the loss of resistance technique. Then test dose of 2-3ml lignocaine with epinephrine 1:200,000 after negative aspiration for blood and CSF was given, 5 minutes later 15 ml of bupivacaine 0.5% was injected as induction then continuous infusion by 5 ml /hour till the end of the surgery.

Then, Sensory block was evaluated in all patients by loss of sensation to pinprick in the midline using a 22 gauge blunt hypodermic needle. Motor block was evaluated using a modified Bromage scale from 1 to 3 (1 = lack of hip flexion, 2

= loss of knee extension, 3 = loss of ankle dorsiflexion).

Patient discomfort was treated with a bolus of IV fentanyl 1 - 2 μg/kg. If more than 2 μg/kg of fentanyl was required to maintain patient comfort, the regional anesthesia technique was considered a failure, and general anesthesia was induced.

For applying the tourniquet after complete sensory block**,** the limb was exsanguinated by elevating for 1 minute and using an Esmarch bandage or tourniquet exsanguinators for emptying the blood vessels from the distal end to the proximal end prior to tourniquet inflation. The optimal timing and angle of elevation for maximal exsanguinations for the leg is 5 min at 45˚. Pressure of inflation is 100 mm hg above the systolic blood pressure.

Intraoperatively, the following parameters were recorded:

- Systolic and diastolic blood pressure and heart rate at (0, 5, 15, 30, 60, 90 minutes).
- Potassium and lactate levels immediately before inflation of the tourniquet and 5 minutes after tourniquet deflation.
- Tourniquet time.
- Tourniquet pain using Wong-baker faces (Figure 1), which is a pain rating scale, 10 minutes after tourniquet inflation and after tourniquet deflation.

Postoperative follow up:

Patients were followed up for immediate post-operative pain which was assessed using "Wong baker faces".

Sample size:

Based on a pilot study, sample size was calculated according to the difference between preoperative and postoperative level of lactate in the three studied groups (0.15 ± 0.08; 0.12 ± 0.07 and 0.16 ± 0.08, respectively) which leads to detect approximately 12.5% clinical significant difference between them with an effect size of 0.41. Assuming $\alpha = 0.05$, power of 80%, so a sample size of 20 patients per group would be required (GPower 301 http://www.psycho.uni-duesseldorf.de).

Statistical analysis

Data were coded and entered using the statistical package SPSS version 21. Data was summarized using mean and standard deviation. Comparisons between groups were done using analysis of variance (ANOVA) with multiple comparisons post hoc test in normally distributed quantitative variables while

Figure 1. Wong-baker faces pain scale [9].

non-parametrical kruskal-Wallis test and Mann-Whitney test were used for non-normally distributed variables .Correlations were done to test for linear relations between quantitative variables by Spearman correlation coefficient. P-values less than 0.05 were considered as statistically significant.

3. Results

60 (out of 67) included in the study. Three patients were excluded due to failure of regional anesthesia followed by induction of general anesthesia, while the other four were excluded due to their lengthy operations (exceeded 90 minutes).

All patients were comparable regarding demographic data including age, sex, ASA & weight (Wt) (Table 1).

Intraoperative hemodynamics

There were statistically significant differences between the three groups values in systolic and diastolic blood pressure at the following time intervals 5, 15 & 30 minutes, and in heart rate at the following time intervals 5 & 15 minutes ($p \leq 0.05$), where there was statistically significant decrease in systolic and diastolic blood pressure and increase in heart rate in the spinal group more than the epidural group and the epidural group more than the femoral-sciatic block group in these time intervals (Table 2).

In the femoral-sciatic block group (the most hemodynamically stable), there were no statistically significant changes in systolic and diastolic blood pressure in different time intervals compared to the baseline value and heart rate showed statistically significant increase in time interval 90 compared to the baseline value. While in the spinal block group, systolic and diastolic blood pressure showed statistically significant decrease compared to the baseline value at most time intervals (5, 15, 30, 60 minutes) and heart rate showed statistically significant increase compared to the baseline value at time intervals 5, 15, 30 minutes. However in the epidural block group, blood pressure showed statistically significant decrease compared to the baseline value at time intervals 15, 30, 60 minutes and heart rate showed statistically significant increase compared to the baseline value at time intervals 15 & 30 minutes (Table 2).

Serum potassium and lactate levels

There was no statistically significant difference between the three groups regarding preoperative and post tourniquet deflation levels of both serum potassium and lactate (Table 3). However, each group showed statistically significant

Table 1. Demographic data & ASA.

	Group F (n = 20)	Group S (n = 20)	Group E (n = 20)	*P* value
Age (years) (mean ±S.D)	38.25 (±10.19)	36.90 (±10.67)	37.05(±11.72)	0. 91
Sex (male no)	11	13	11	1.00
ASA (no of ASA I)	15	13	11	0.32
Wt (kg) (mean ±S.D)	67.00 ±4.87	65.80 ±5.97	68.35 ±6.67	0.42

Table 2. Hemodynamic changes (pressure in mm hg & HR beat/min) in the three study groups and their p values compared to baseline.

	Group F (20)		Group S (20)		Group E (20)		P value
	Mean ± SD	P value from baseline	Mean ± SD	P value from baseline	Mean ± SD	P value from baseline	
systolic BP (0)	135.80 ± 14.13		132.50 ± 12.64		131.00 ± 12.31		0.497
systolic BP (5)	133.80 ± 13.50	0.056	120.30 ± 14.13	0.000*	128.30 ± 12.76	0.062	0.009*
systolic BP (15)	132.70 ± 13.07	0.086	118.00 ± 13.86	0.000*	123.40 ± 12.73	0.000*	0.003*
systolic BP (30)	131.50 ± 10.29	0.072	119.70 ± 10.77	0.000*	121.60 ± 13.43	0.000*	0.004*
systolic BP (60)	129.85 ± 11.03	0.061	126.55 ± 8.94	0.007*	123.70 ± 12.04	0.005*	0.203
systolic BP (90)	130.55 ± 10.85	0.060	127.05 ± 8.85	0.019	126.65 ± 11.02	0.014	0.424
Diastolic BP (0)	81.80 ± 6.57		78.40 ± 7.2		82.85 ± 4.68		0.072
Diastolic BP (5)	81.70 ± 5.57	0.915	71.40 ± 7.50	0.000 *	82.05 ± 5.37	0.399	< 0.001
Diastolic BP (15)	80.45 ± 4.94	0.210	68.95 ± 7.05	0.000*	78.20 ± 6.53	0.002*	< 0.001
Diastolic BP (30)	78.30 ± 4.82	0.115	72.30 ± 4.74	0.003*	76.40 ± 5.84	0.000*	0.002
Diastolic BP (60)	79.00 ± 5.04	0.061	76.15 ± 4.83	0.214	76.50 ± 6.21	0.000*	0.199
Diastolic BP (90)	78.90 ± 5.08	0.025	75.70 ± 6.53	0.158	76.70 ± 5.09	0.011	0.191
HR (0)	76.75 ± 9.66		81.15 ± 13.41		81.90 ± 15.07		0.401
HR (5)	76.90 ± 9.48	0.829	89.90 ± 15.19	0.000*	85.70 ± 15.37	0.027	0.012
HR (15)	78.80 ± 9.69	0.022	91.75 ± 14.61	0.000*	84.85 ± 12.63	0.004*	0.007
HR (30)	79.35 ± 9.03	0.018	88.10 ± 12.73	0.000*	83.95 ± 12.24	0.003*	0.062
HR (60)	81.25 ± 8.17	0.030	84.65 ± 11.74	0.019	82.65 ± 10.78	0.703	0.582
HR (90)	80.55 ± 9.38	0.002*	82.05 ± 11.99	0.573	84.35 ± 12.63	0.199	0.573

*Data are presented as mean & ± SD; *(0) is pre-operative measurement; *(5, 15, 30, 60, 90) minutes after induction of anesthesia. *P value is significant when ($P < 0.05$).

Table 3. Potassium and lactate level changes (mmol) pre-operative & 5 minutes post-deflation in the three study groups.

	Group F (20)		Group S (20)		Group E (20)		P value
	Mean ± SD	P value from baseline	Mean ± SD	P value from baseline	Mean ± SD	P value from baseline	
K (pre operative)	3.88 ± 0.51		4.07 ± 0.55		4.04 ± 0.52		0.487
K (post deflation)	4.09 ± 0.61	0.004*	4.24 ± 0.60	0.006*	4.23 ± 0.56	0.000*	0.067
Lactate (pre operative)	1.18 ± 0.59		1.09 ± 0.44		0.92 ± 0.23		0.054
Lactate (post deflation)	1.31 ± 0.61	0.004*	1.17 ± 0.47	0.000*	0.94 ± 0.28	0.000 *	0.051

increase in post deflation levels of both serum potassium and lactate when compared to the pre-operative values of each group, and the increase was directly proportional to the duration of tourniquet (Table 3).

Tourniquet pain:

There was no statistically significant difference between the three groups regarding tourniquet pain neither intraoperatively nor post operatively (Table 4).

However, each group showed statistically significant increase in postoperative tourniquet pain sensation when compared to the intraoperative values of each group, and the increase was directly proportional to the duration of tourniquet (Table 4).

4. Discussion

In the current study, we evaluated the consequences of the arterial tourniquet and reperfusion injury by assessing intraoperative hemodynamics, serum potassium & lactate levels changes, and tourniquet pain under the effect of three different regional blocks, femoral-sciatic, spinal & epidural blocks. And the study revealed that there is no relation or effect of the block on the degree of the metabolic, hemodynamic changes tourniquet-induced pain, and it is only affected by the tourniquet duration irrespective to the type of regional block.

Reperfusion of ischemic tissue results in potentially harmful pathophysiological reactions, such as production of oxygen free radicals which are released into the circulation after tourniquet deflation causing cellular injuries involving lipids, proteins & DNA leading to increase in serum potassium and lactate levels [10]. Some studies showed less hemodynamic and metabolic changes resulted from tourniquet application in patients undergoing regional anesthesia compared with general anesthesia [11]. In addition, local anesthetics were found to inhibit migration, enzyme release and superoxide anion formation of polymorphonuclear leukocytes involved in cellular injury [12].

A study done in 2002 by H. lawama *et al.* [13] who evaluated the effect arterial tourniquet on the 12 patients underwent total knee arthroplasty using tourniquet and received epidural anesthesia with propofol infusion and laryngeal mask. They found significant metabolic changes after tourniquet release, as the arterial blood PH and base excess were decreased at 1, 3 & 1, 3, 5 min respect-

Table 4. Intra-operative and directly post-operative tourniquet pain (using "Wong-baker faces") in the three study groups.

	Group F (20)		Group S (20)		Group E (20)		*P* value
	Mean ± SD	*P* value Intra & post-operative	Mean ± SD	*P* value Intra & post-operative	Mean ± SD	*P* value Intra & post-operative	
Intraoperative tourniquet pain	0.30 ± 0.73		0.20 ± 0.62		0.30 ± 0.73		0.872
Post-operative tourniquet pain	0.60 ± 1.12	0.003*	0.60 ± 1.31	0.002*	0.1 ± 1.23	0.003*	0.902
tourniquet time (minutes)	50.00 ± 14.78		44.00 ± 17.67		53.50 ± 13.77		0.156

tively after tourniquet release. For serum lactate the levels were increased all time after the release of tourniquet. While serum potassium readings were increased at 1, 3, 5, 15 minutes after tourniquet release.

Kosucu *et al*. [10] assessed the reperfusion injury of the arterial tourniquet on 60 patients underwent knee surgeries and divided into 3 groups received spinal anesthesia (S group), sevoflurane for induction and Maintenance (I group), and the third group received propofol for total intravenous anesthesia (T group). Metabolic status was assessed using different markers; ischemia modified albumin and malondialdehyde. They concluded that TIVA with propofol has more protective effect than inhalational and spinal anesthesia in tourniquet related ischemia-reperfusion. This is in agreement to our results regarding spinal & regional anesthesia in general, as we found that different types of regional anesthesia, including spinal anesthesia, showed statistically significant rise in the metabolites we measured between pre-inflation and post-inflation values.

Tourniquet pain can still be felt with spinal and epidural anaesthesia, despite adequate sensory anaesthesia, which is determined by pinprick, this is because that, inadequate concentrations of local anaesthetic may not block the larger nerve fibres carrying pressure-pain sensation. In spinal anaesthesia, the loss of sensation to touch is slower in onset and regresses more rapidly than the loss of sensation to pinprick, this may be due to differential block of different nerve fiber types and that differential block is greater during regression of anesthesia which occurs at the end of the surgery [14].

C-fibres are inhibited by fast pain impulses conducted through myelinated A-delta fibres. Mechanical compression leads to loss of conduction in nerve fibres and large A-delta nerve fibres are blocked first before small C-ibres. And It is suggested that after ≈ 30 min of tourniquet inflation, the larger A-delta fibres will be blocked, leaving the uninhibited C-fibres still-functioning [8]. Another theory is introduced through the *in vitro* finding that smaller unmyelinated C-fibres are more resistant to conduction block which induced by local anaesthetic than larger myelinated A-fibres. After intrathecal injection of a sufficient dose of local anaesthetic, conduction in both A- and C-fibres is blocked. However, by time as the concentration of local anaesthetic in the cerebrospinal fluid decreases, C-fibres start to conduct impulses before the A-fibres, resulting in a dull tourniquet pain although the presence of an apparently adequate anaesthesia which assessed by pinprick [15].

Tetzlaff *et al*. [16] studied the effecte of three different regional anesthetic techniques (spinal block, lumbar epidural block, and the third was the same as the second group but the solution was alkalinized with bicarbonate) on the incidence of lower extremity tourniquet pain on 60 patients performing orthopedic procedures on lower extremity using pneumatic tourniquet for more than 60 minutes duration. Their study showed a lower incidence of tourniquet pain with spinal anaesthesia compared with epidural anaesthesia to the same sensory level. However, this difference didn't occur when the epidural was done using alkalinised local anaesthetic solution, suggesting increased penetration of the larger nerve fibres by the alkalinized local anaesthetic.

Fuzier *et al.* [17] assessed thigh tourniquet tolerance using different approaches of sciatic block, a Labat's and a posterior popliteal in 120 patients with below-knee surgery. No statistically significant difference was observed between groups regarding tourniquet tolerance & they conclude that despite the complete sensory block of the posterior femoral cutaneous nerve in almost all patients, Labat's approach of the sciatic nerve didn't provide better tolerance to thigh tourniquet t than the popliteal approach.

5. Recommendations

Our recommendations are to increase the sample size to conduct the study on larger group of population and to widen the criteria of patients' selection as ASA III, IV, obese patients and elderly and to conduct other studies using different adjuvants to the local anesthetic drug used in the block to evaluate if these agjuvants are effective or not in reducing tourniquet pain.

6. Conclusion

We conclude that the effects of three different types of anesthesia (femoral-sciatic, spinal and epidural block) are the same regarding the degree of tourniquet pain which is related to the duration of tourniquet inflation.

References

[1] Oragui, E., Parsons, A., White, T., Longo, U.G. and Khan, W.S. (2011) Tourniquet Use in Upper Limb Surgery. *Hand*, **6**, 165-173. https://doi.org/10.1007/s11552-010-9312-6

[2] Budić, I., Pavlović, D., Cvetković, T., *et al.* (2010) The Effects of Different Anesthesia Techniques on Free Radical Production after Tourniquet-Induced Ischemia-Reperfusion Injury at Children's Age. *Vojnosanitetski Pregled*, **67**, 659-664.

[3] Girardis, M., Milesi, S., Donato, S., *et al.* (2000) The Hemodynamic and Metabolic Effects of Tourniquet Application during Knee Surgery. *Anesthesia & Analgesia*, **91**, 727-731. https://doi.org/10.1213/00000539-200009000-00043

[4] Deloughry, J. and Griffiths, R. (2009) Arterial Tourniquets. *Continuing Education in Anaesthesia*, *Critical Care & Pain*, **9**, 56-60.

[5] Hagenouw, R.R.P.M., Bridenbaugh, P.O., Van Egmond, J. and Stuebing, R. (1986) Tourniquet Pain: Volunteer Study. *Anesthesia and Analgesia*, **65**, 1175-1180. https://doi.org/10.1213/00000539-198611000-00013

[6] Fuselier, C.O., Binnig, T. and Dobbs, B.M. (1988) A Study of the Use of a Double Tourniquet Technique to Obtain Hemostasis in Combination with Local Standby Sedation during Podiatric Surgery. *Journal of Foot Surgery*, **27**, 515-527.

[7] Kam, P.C., Kavanagh, R. and Yoong, F.F. (2001) The Arterial Tourniquet: Pathophysiological Consequences and Anaesthetic Implications. *Anaesthesia*, **56**, 534-545. https://doi.org/10.1046/j.1365-2044.2001.01982.x

[8] Gielen, M.J. and Stienstra, R. (1991) Tourniquet Hypertension and Its Prevention: A Review. *Regional Anaesthesia*, **16**, 191-194.

[9] Wong, D.L., Hockenberry-Eaton, M., Wilson, D., Winkelstein, M.L. and Schwartz, P. (2001) Wong's Essentials of Pediatric Nursing. 6th Edition, Mosby, Inc., St.

Louis, MO, 1301.

[10] Kosucu, M., Coskun, I., Eroglu, A., Kutanis, D., Mentese, A., Karahan, S.C., *et al.* (2014) The Effects of Spinal, Inhalation, and Total Intravenous Anesthetic Techniques on Ischemia-Reperfusion Injury in Arthroscopic Knee Surgery. *BioMed Research International*, **2014**, Article ID: 846570. https://doi.org/10.1155/2014/846570

[11] Saricaoglu, F., Dal, D., Salman, A.E., Doral, M.N., Kilinc, K. and Aypar, U. (2005) Ketamine Sedation during Spinal Anesthesia for Arthroscopic Knee Surgery Reduced the Ischemia-Reperfusion Injury Markers. *Anesthesia & Analgesia*, **101**, 904-909. https://doi.org/10.1213/01.ANE.0000159377.15687.87

[12] Welters, I.D., Menzebach, A., Langefeld, T.W., Menzebach, M. and Hempelmann, G. (2001) Inhibitory Effects of S-(−) and R-(+) Bupivacaine on Neutrophil Function. *Acta Anaesthesiologica Scandinavica*, **45**, 570-575. https://doi.org/10.1034/j.1399-6576.2001.045005570.x

[13] Iwama, H., Kaneko, T., Ohmizo, H., Furuta, S., Ohmori, S. and Watanabe, K. (2002) Circulatory, Respiratory and Metabolic Changes after Thigh Tourniquet Release in Combined Epidural-Propofol Anaesthesia with Preservation of Spontaneous Respiration. *Anaesthesia*, **57**, 584-605. https://doi.org/10.1046/j.1365-2044.2002.02509_2.x

[14] Rocco, A.G., Raymond, S.A., Murray, E., *et al.* (1985) Differential Spread of Blockade of Touch, Cold, and Pinprick during Spinal Anaesthesia. *Anesthesia and Analgesia*, **64**, 917-923. https://doi.org/10.1213/00000539-198509000-00011

[15] Gissen, A.J., Covino, B.G. and Gregus, J. (1980) Differential Sensitivities of Mammalian Nerve Fibres to Local Anesthetic Agents. *Anesthesiology*, **53**, 467-474. https://doi.org/10.1097/00000542-198012000-00006

[16] Tetzlaff, J.E., Yoon, H.J. and Walsh, M. (1993) Regional Anesthetic and the Incidence of Tourniquet Pain. *Canadian Journal of Anaesthesia*, **40**, 591-595. https://doi.org/10.1007/BF03009693

[17] Fuzier, R., Hoffreumont, P., Bringuier-Branchereau, S., Capdevila, X. and Singelyn, F. (2005) Does the Sciatic Nerve Approach Influence Thigh Tourniquet Tolerance during Below-Knee Surgery? *Anesthesia & Analgesia*, **100**, 1511-1514. https://doi.org/10.1213/01.ANE.0000148119.99913.30