Comparative Study Between Adductor Canal Block, Femoral Nerve Block and Epidural Analgesia for Management of Post-Operative Pain in Total Knee Replacement

Abstract:

Background: Total knee arthroplasty (TKA) is a common surgery that is associated with moderate to severe pain. Early ambulation and physical therapy are essential for functional recovery and long-term functional outcome after TKA as well as for reducing the immobility related complications. Hence, optimal pain relief while maintaining the motor function remains the mainstay in postoperative pain management after TKA.

Patients and Methods: This prospective randomized controlled open-labelled study was carried out at Tanta University Hospital, Orthopedic Surgery Department from January 2020 to February 2021.

Results: This prospective randomized controlled study was carried out Tanta university on 90 patients admitted for Total Knee Arthroplasty (TKA) After approval from ethics and research committee.

Conclusion: Adductor canal nerve block provide better postoperative pain relieve with lower NRS after TKA than femoral and epidural blocks. It provides more stability of hemodynamic parameter and longer time for the 1st time of analgesic request. Also, total consumption of morphine in 1st postoperative day is lower than femoral and epidural blocks.

Keywords: Total knee arthroplasty ،femoral nerve block, Adductor canal block and Epidural Group

Introduction:

Major knee surgery such as total knee joint replacement and anterior cruciate ligament reconstruction is associated with moderate to severe postoperative pain. [(1)]These lower limb procedures are amenable to regional anesthesia techniques, which reduce neuroendocrine stress responses, central sensitization of nervous system, and muscle spasm, which occur in response to painful stimuli. [(2)]

Total knee arthroplasty (TKA) is associated with severe postoperative pain leading to hypertension, tachycardia, increased O_2 demand, and myocardial stress. Pain increases sympathetic activity, releases catabolic hormones, and reduces immunity. [(3)]

Postoperative pain is still inadequately relieved, despite substantial improvements in the knowledge of the mechanisms and treatment of pain. [(4)]In addition to the physiological ill effects, the presence of postoperative symptoms including pain significantly contributes to patient's dissatisfaction with their anesthetic and surgical experience. [(5)]It has been proven beyond doubt that inadequately treated postoperative pain may lead to chronic pain. [(6)]

The use of epidural analgesia in management of postoperative pain following orthopedic surgeries has evolved as a critical component of multimodal approach to achieve the goal of pain relief, early mobilization, and improved compliance with physiotherapy resulting in overall improved outcome. [(7)]

Peripheral nerve blockade is known to provide excellent postoperative analgesia after knee surgery. Several studies suggest that: pain relief is similar, and opioid-related adverse effects are less compared with intravenous patient-controlled analgesia, and similar analgesia with less hypotension compared with certain regimes of epidural analgesia. However, femoral nerve block (FNB) reduces the strength of quadriceps muscle, which may increase the risk of postoperative falls and delay early postoperative mobilization, influencing patient satisfaction. Therefore, peripheral nerve blockade with preserved muscle function and adequate analgesic effect is desirable. [(8)]

Adductor canal block (ACB) is a relatively new alternative for post-TKA pain management. Regional anesthesia is deposited within an adductor canal that can be easily visualized at the middle third of the thigh with use of ultrasonography. Consequently, ACB can be performed with a high success rate. Anatomical study of adductor canal showed that an adductor canal contained multiple afferent sensory nerves (e.g. saphenous nerve, medial femoral cutaneous, etc. (but only a single efferent motor nerve (vastus medialis of the quadriceps muscle (that potentially affected motor function. [9]

The aim of the present study was to compare the efficacy of continuous adductor canal block, femoral nerve block or epidural analgesia in management of post-operative pain after total knee replacement.

Patients and methods

This prospective randomized controlled open-labelled study was carried out at Tanta University Hospital, Orthopedic Surgery Department from January 2020 to February 2021.

This study included 90 patients aged above 25 years of both sex, with the American Society of Anesthesiologists (ASA) classification I or II and scheduled for elective total knee replacement surgery.

Exclusion criteria were Coagulopathy, Infection at site of intervention, Hypersensitive to the study drugs, Bilateral TKA, Chronic narcotic use, Neuromuscular disease and Pervious vascular operation.

The patient was allocated according to technique used into three groups; 30 patients each; by using computer-generated software introduced into sealed closed envelopes.

Group I: Epidural Group (EG) (n:30)

The epidural catheter was inserted preoperatively and at the end of the operation the epidural analgesia was conducted with 5 ml of 0.125% Bupivacaine, then infusion at rate of 5 ml/hr for 1st postoperative day.

Group II: Femoral Nerve Block Group (FNBG): (n:30)

Femoral nerve catheter was inserted using ultrasound guidance postoperatively, and 5 ml bolus dose of 0.125% bupivacaine was injected and then infusion at rate of 5 ml/hr for 1st postoperative day.

Group III: Adductor Canal Block Group (ACBG): (n:30)

Adductor Canal catheter was inserted using ultrasound guidance postoperatively, and 5 ml bolus dose of 0.125% bupivacaine was injected and then infusion at rate of 5 ml/hr for 1st postoperative day.

Primary outcome**:** Postoperative Numeric Rating Scale (NRS) pain score to detect efficacy of block, and secondary outcomes were time of first analgesic requirement, total morphine consumption, any undesirable side effects and overall patient satisfaction with analgesia.

Results

Patients' demographic data (age, BMI, weight, sex and duration of surgery) were insignificantly different among the three groups. [Table 1]

Heart rate was significantly increased at 12 and 18 hours postoperatively in group I and II compared to group III ($p < 0.05$) and there was insignificant change between group I and group II. ($p > 0.05$)

There was insignificant change among the three groups at PACU, 2, 4, 6 and 24 hours postoperatively. ($p > 0.05$) [Figure 1]

Mean arterial blood pressure was significantly increased at 12 and 18 hours postoperatively in group I and II compared to group III (P<0.05) and was insignificant change between group I and group II. (p >0.05)

There was insignificant change among the three groups at PACU, 2, 4, 6 and 24 hours postoperatively. (p>0.05) [Figure 2]

NRS was significantly increased at 12 and 18 hours postoperatively in group I and II compared to group III (P<0.05) and was insignificant change between group I and group II. (p>0.05)

There was insignificant change among the three groups at PACU, 2, 4, 6 and 24 hours postoperatively. (p>0.05) [Figure 3]

Overall patient satisfaction with analgesia on second postoperative day was ranged from 4 “very satisfied” (15 patients in group I, 16 patients in group II and 25 patients in group III), 3 “satisfied” (12 patients in group I, 7 patients in group II and 5 patients in group III(,2 “dissatisfied” (1 patient in group I, 3 patients in group II and 0 patient in group III(and 1 “very dissatisfied” (2 patients in group I, 4 patients in group II and 0 patients in group III)

Patient satisfaction was significantly higher in group III compared to group I and group II on the second postoperative day. (P< 0.05). [Figure 4]

Side effects among the three groups as vomiting, bradycardia, hypotension and failed cases were insignificantly different among the three groups. [Table 2]

		Group I (n = 30)	**Group II (n = 30)**	**Group III (n = 30)**	**P value**
Age (years)	**Range**	30-72	27-73	33-71	0.665
	Mean ± SD	55.2 ± 7.88	56.03 ± 8.79	51.3 ± 7.72	
Sex	**Male**	19 (63%)	20 (67%)	17 (57%)	0.718
	Female	11 (37%)	10 (33%)	13 (43%)	
BMI (kg/m^2)	**Range**	18.6-35.2	19.5-34.8	20.8-34.7	0.337
	Mean ± SD	27.31 ± 5.61	26.09 ± 4.63	27.93 ± 4.33	
ASA physical status	**ASA I**	22 (73%)	21 (70%)	23 (77%)	0.843
	ASA II	8 (27%)	9 (30%)	7 (23%)	
Duration of surgery (min)	**Range**	130-180	120-180	130-190	0.512
	Mean ± SD	153 ± 19.5	150.33 ± 23.41	147 ± 16.64	

ASA: American Society of Anesthesiologist, BMI: body mass index

Table 1: Demographic data among the three groups

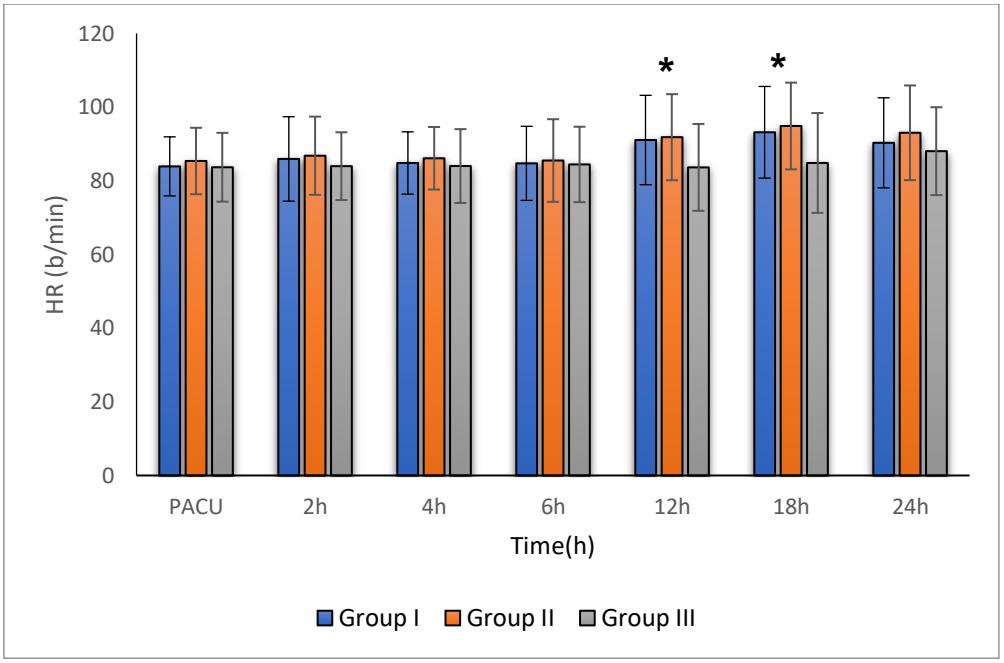

Figure 1: Comparison between HR changes in the studied groups (b/min)

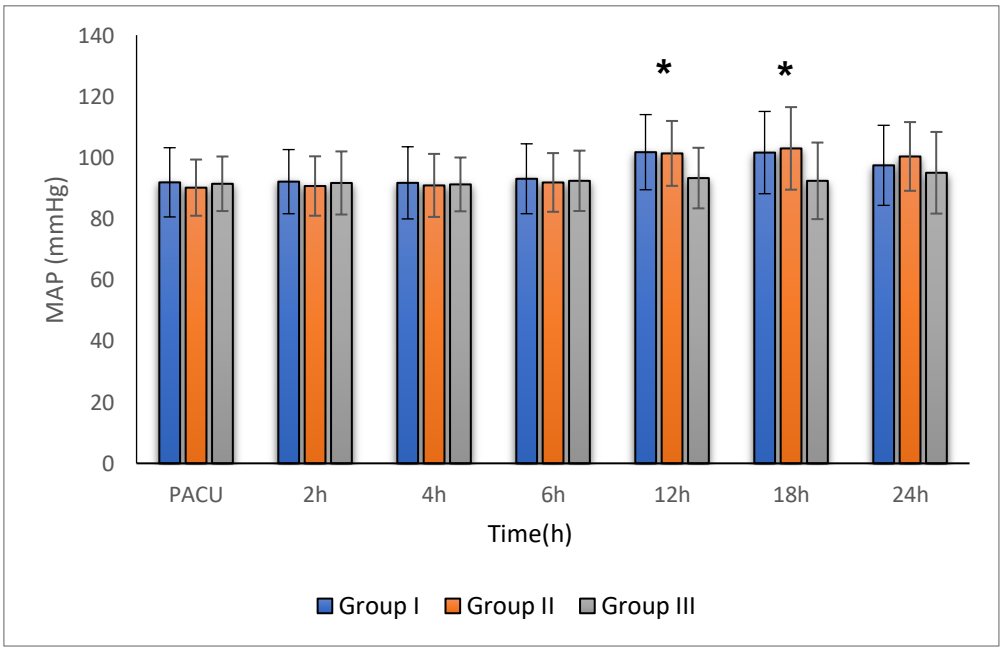

Figure 2: Comparison between MAP changes in the studied groups (mmHg)

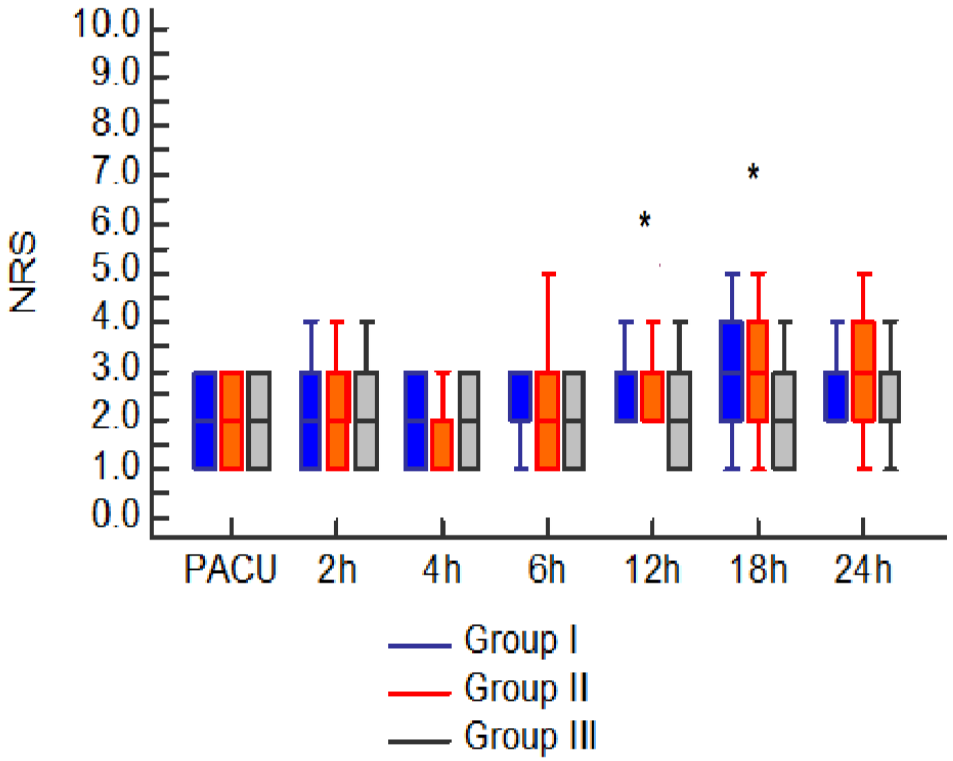

Figure 3: Comparison between NRS changes in the studied groups

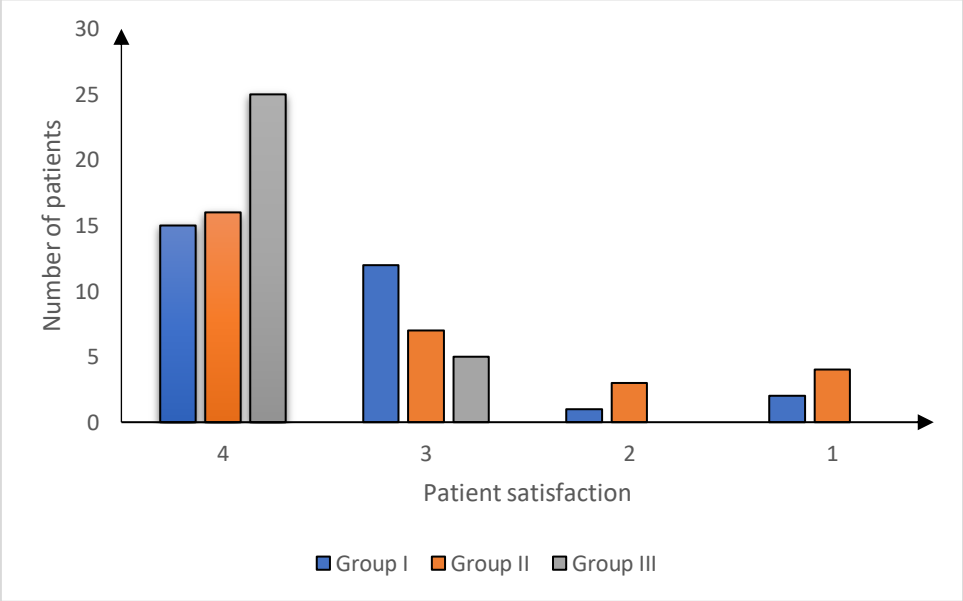

Figure 4: Patient satisfaction in the studied groups

Post-operative side effects in studied groups				
	Group I (n = 30)	**Group II (n = 30)**	**Group III (n = 30)**	**P value**
Nausea	9 (30%)	2 (6.7%)	3 (10%)	**0.026***
Vomiting	1 (3.3%)	7 (23.3%)	4 (13.3%)	0.075
Bradycardia	2 (6.7%)	6 (20%)	5 (16.7%)	0.311
Hypotension	2 (6.7%)	1 (3.3%)	2 (6.7%)	0.809
Failed cases	2 (6.7%)	1 (3.3%)	1 (3.3%)	0.770

Table 2: Post-operative side effects in studied groups

Discussion

Pain is an individual experience, and the postoperative pain is difficult to predict, especially, if the level of surgical intervention differs from the initial plan. [10] Severe postoperative pain after TKA can not only be a patient suffering but also negatively affect postoperative recovery. Extensive tissue damage in major operations, such as TKA, cause immediate changes in the endocrine system and central, peripheral, and sympathetic nervous systems, and stimulate catabolic hormone release including cortisol, glucagon, growth hormone, and catecholamine, resulting in compromised immunity, increased oxygen demand, and higher strain on the cardiovascular system. [11]

Peripheral nerve blocks are associated with less pain and lower odds of unplanned hospital admission compared to systemic analgesia. The decision regarding continuous versus single injection depends on the expected surgical trauma and patient factors. [12]

Among the regional analgesia techniques, continuous epidural analgesia (CEA) has been the mainstay for a considerable period. Peripheral neural blockade (femoral +/- sciatic nerve, lumbar plexus) is also used, mostly by paresthesia with or without nerve stimulation techniques. Ultrasound guided needle and catheter placement is observed to be technically superior, with much accurate needle placement. [13]

Femoral nerve block (FNB) is an analgesic technique that blocks sensation to the knee to reduce pain following surgery. [13] FNB is often considered as the gold standard for postoperative pain treatment after total knee arthroplasty. However, have been shown to reduce quadriceps muscle strength and are associated with an increased risk of falling postoperatively.[14]

The adductor canal block gained attention from anesthesia and orthopedic communities. The desire to produce analgesia without loss of motor control to the thigh is beneficial. Benefits of this technique may include shorter hospital stays, earlier and more efficient rehabilitation, and pain control.[15]

In our study we aimed to compare the management of postoperative pain in total knee replacement using continuous adductor canal block, femoral nerve block or epidural analgesia, evaluation of postoperative pain was the primary outcome, while total dose of analgesic consumption, first analgesic request, any undesirable side effects and overall patient

satisfaction with analgesia post operatively were secondary outcomes in our study.

The studied groups were comparable regarding the demographic data (age, sex, BMI, and ASA physical status) were insignificantly different. Also, there was statistically insignificant difference as regarding the duration of surgery.

As regard the postoperative pain score (NRS); in our study; there was significant increase in NRS at 12 and 18 hours postoperatively in group I (EG) and II (FNBG) compared to group III (ACBG) and was insignificant change between group I (EG) and group II (FNBG). Also, there was insignificant change among the three groups at PACU, 2, 4, 6 hours postoperatively and significant increase at 24 hours postoperatively in the three studied groups.

In consistence with our results, **Hanson *et al 2014*** [16] studied the effect of the continuous adductor canal block compared with that of placebo in patients undergoing total knee arthroplasty and they concluded that, the median resting pain scores at the 18 hours was significantly reduced for the ACB group compared with that of the other group.

Also, **Kayupov *et al 2018*** [17] compared the analgesic and functional outcomes between continuous ACB and epidural analgesia in TKA and showed that, patients randomized to continuous ACB group had significantly lower pain scores on 1st postoperative day compared to patients who received epidural analgesia.

Moreover, **Alsheikh *et al 2020*** [18] evaluated the effectiveness and early outcomes of adductor canal blockade and continuous epidural analgesia in unilateral total knee replacement and reported that, pain was significantly higher among the continuous epidural analgesia group than the adductor canal blockade group after 8 h.

On the contrary, **Shanthanna *et al 2012*** [19] compared continuous epidural analgesia (CEA) +fentanyl and continuous femoral block (CFB) +fentanyl for post-operative analgesia in total knee replacement. They demonstrated that, VAS scores were significantly high in the femoral group at 6 h, after which there was a declining trend, and scores were essentially similar from 24 h**.** This can be attributed to high dose of bupivacaine and addition of fentanyl in their study.

Also**, Hegazy *et al 2015*** [20] were studied patients randomized to receive either adductor canal block or femoral nerve block for total knee replacement. They noted that, there was no significant difference between the study groups regarding the NRS after 12 hours. These difference from our study can be explained by the relatively high concentration of local anesthetics used as a single dose in their study.

Moreover, **Memtsoudis *et al 2015*** [21] evaluated patients scheduled for bilateral total knee arthroplasty and randomized to receive ultrasound-guided FNB on one leg and ACB on the other, in addition to combined spinal epidural anaesthesia. The primary outcome was comparative postoperative pain in either extremity at 6 to 8, 24 and 48 hours postoperatively. They showed that, no significant differences were seen between extremities at any time point with regard to pain in the quantitative comparison using visual analogue scale (VAS) scores. These difference between our study can attributed to high concentration of bupivacaine and use of combined spinal epidural in both groups.

In addition, **Mai *et al 2018*** [12] studied patients scheduled for knee arthroscopy. Patients divided into three equal groups (Group I) received basic analgesia in the form of paracetamol and diclofenac, (Group II) received ultrasound guided femoral nerve block and (Group III)

received ultrasound guided adductor canal block. They observed that, comparison of the mean value of NRS score showed no significant difference between femoral nerve block and adductor canal block which may be due to relatively higher single concentration of local anesthetics.

Furthermore, **Armanious *et al 2020*** [22] evaluated patients scheduled for uni-compartmental knee arthroplasty with combined spinal epidural anaesthesia. Patients received either FNB or ACB. They found that, no difference between the groups regarding postoperative VAS at rest except at 24 h was significantly lower in FNB group. This can be explained by the higher concentration of local anesthetics and addition of epinephrine in their study.

Concerning the time to first analgesic requirement**,** it was significantly increased in group III (ACBG) compared to group I (EG) and group II (FNBG) and there was insignificant difference between group I (EG) and group II (FNBG)

In contrast to our results, **Abdallah *et al 2016*** [23] compared the adductor canal block with femoral nerve block after anterior cruciate ligament reconstruction and they noted that, the first time to introduce morphine showed no significant difference between two groups. This can be explained by high concentration of bupivacaine and addition of epinephrine.

Moreover, **Mai *et al 2018*** [12] demonstrated that, the first time to introduce morphine showed no significant difference between FNB (group II) and ACB (group III). Also, **El-Feky *et al 2018*** [15] evaluated the reliability of the postoperative pain control using adductor canal block compared with that using the femoral nerve block after knee arthroplasty and they postulated that, there was no statistically significant difference between the 2 groups as regards time to first pethidine requirement post-operatively. This can be explained by the use of relatively higher concentration of single dose of local anesthetics.

Regarding the total dose of morphine consumed in the 1st 24 hours was significantly decreased in group III (ACBG) than group I (EG) and group II (FNBG) and there was insignificant change between group I (EG) and group II (FNBG).

In accordance to our study, **Lund *et al 2011*** [24] evaluated eight patients receiving a continuous adductor canal blockade after total knee arthroplasty. They demonstrated that, the continuous adductor canal blockade for 48h after TKA was associated with low mean pain scores at rest and low mean requirements for supplemental morphine.

Also, **Koh *et al 2017*** [25]compared the analgesic efficacy and functional recovery between adductor canal block and femoral nerve block after total knee arthroplasty. They found that, ACB provides comparable analgesic efficacy and less total opioid consumption and also facilitates earlier mobilization by sparing quadriceps strength compared with FNB.

Furthermore, **Alsheikh *et al 2020*** [18] demonstrated that, total opioid consumption was significantly decreased after using ACB (group III) compared with epidural analgesia (group I).

Inconsistence to our results, **Hegazy *et al 2015*** [20] and **Mai *et al 2018*** [12] found that, there was no significant difference between group II (FNBG) and group III (ACBG) regarding the total morphine consumption which was significantly decreased in our study in group III (ACBG). These difference can be related to the use of relatively higher concentration of single dose of local anesthetics.

Also, **Tan *et al 2018*** [26] compared the total opioid consumption with adductor canal block and femoral nerve block after total knee arthroplasty. They postulated that, there was no significant difference

between the ACB and FNB groups postoperatively regarding to total opioid consumption, which can be due to high concentration of bupivacaine with addition of epinephrine.

Concerning patient satisfaction, patients were very satisfied in group III (ACBG) compared to group I (EG) and group II (FNBG) on the second postoperative day.

Also, **Shanthanna *et al 2012*** [19] concluded that, although patients in continuous epidural group were slightly more satisfied when compared with femoral group but still statistically insignificant.

In contrast with our results, **Memtsoudis *et al 2015*** [21] , **Koh *et al 2017*** [25] **,Tan *et al 2018*** [26] and **Armanious *et al 2020*** [22] showed that patient satisfaction score had no significant difference between adductor canal block and femoral nerve block which can attributed to high concentration of bupivacaine and addition of epinephrine in their studies.

Regarding to side effects in our study**,** Nausea was significantly increased in group I (EG) than group II (FNBG) and group III (ACBG). while vomiting, bradycardia, hypotension and failed cases were insignificantly different among the three studied groups.

In agreement to our results, **Hegazy *et al 2015*** [20], **Tan *et al 2018*** [26] and **Armanious *et al 2020*** [22] observed that, nausea and vomiting show no significant difference between femoral nerve group (group II) and adductor canal block group (group III)

Also, **Alsheikh *et al 2020*** [18] showed that, the incidence of nausea and vomiting were significantly decreased after using adductor canal block compared with epidural analgesia.

In contrast to our results, **Fowler *et al 2008*** [1] found that, hypotension occurred more frequently among patients who received epidural than femoral nerve block and adductor canal block and there was no significant difference in the incidence of nausea and vomiting in epidural group, femoral nerve block group and adductor canal group.

Also, **Kozian *et al 2017*** [27] noted that, during the first 24 hours after total knee arthroplasty, nausea and vomiting showed insignificant differences between epidural group and femoral nerve block group. Also, arterial hypotension was more frequent in the EA group in comparison with the FNB group.

Moreover, **Park *et al 2017*** [28] compared the benefits of continuous femoral nerve block (FNB) combined with single injection sciatic nerve block (SNB(with those of epidural analgesia for postoperative pain management after TKR. They observed that, the incidence of patients with side effects was significantly higher in the epidural analgesia group than the peripheral nerve block group.

As regard hemodynamic changes; in our study; the heart rate and mean arterial blood pressure changes showed significant increase at 12 and 18 hours postoperatively in group I (EG)and group II (FNBG) compared to group III (ACBG) and insignificant change between group I (EG) and group II (FNBG) Also, there was insignificant change among the three groups at PACU, 2, 4, 6 hours postoperatively and significant increase at 24 hours postoperatively in the three studied groups.

Although, there was a lack of literature about the comparison of continuous epidural, continuous femoral nerve block and continuous adductor canal block in hemodynamics, our study in agreement with **Dauri *et al 2003*** [29] who compared the effect of continuous epidural to continuous femoral block for knee surgery and revealed that, there was no significant difference in hemodynamic

changes between group I (EG) and group II (FNBG).

Also, **Vishwanatha *et al 2017*** [30] studied continuous femoral nerve blockade (CFNB) and continuous epidural analgesia (CEA) for postoperative pain control in knee surgeries. Continuous infusion with 0.0625% bupivacaine and fentanyl 2 μg/ml started postoperatively in both groups and they found that, there was no significant hemodynamic changes between group I (EG) and group II (FNBG).

Moreover, **Arjun BK *et al 2019*** [31] reported that, patients received ultrasound-guided adductor canal block and popliteal sciatic block were hemodynamically stable throughout the procedure.

Also, **Kozian *et al 2017*** [27] compared clinical efficiency and adverse events of pain therapy of an established EA+PCA and a modified FNB+PCA protocol. They reported that, arterial hypotension was more frequent in the EA group in comparison with the FNB group.

References

1. Fowler SJ, Symons J, Sabato S, Myles PS. Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. British Journal of Anaesthesia.2008;100:154–16
2. Adams HA, Saatweber P, Schmitz CS, Hecker H. Postoperative pain management in orthopaedic patients: no differences in pain score, but improved stress control by epidural anaesthesia. European Journal of Anaesthesiology. 2002; 19:658 – 65.
3. Burton D, Nicholson G, Hall G. Endocrine and metabolic response to surgery. Continuing Education in Anaesthesia, Critical Care & Pain. 2004; 4:144 7.
4. Apfelbaum JL, Chen C, Mehta SS, Gan TJ. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. Anesthesia & Analgesia. 2003; 97:534-40
5. Tong D, Chung F, Wong D. Predictive factors in global and anesthesia satisfaction in ambulatory surgical patients. Anaesthesiology. 1997; 87:856 – 64.
6. Wang L, Guyatt GH, Kennedy SA, et al. Predictors of persistent pain after breast cancer surgery: a systematic review and meta-analysis of observational studies. Canadian Medical Association Journal. 2016; 188:352–361
7. Richman JM, Wu CL. Epidural analgesia for postoperative pain. Anaesthesiology. 2005; 23:125 40
8. Paul JE, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. Anaesthesiology.2010;113:1144–1162
9. Manickam, B. et al. Feasibility and efficacy of ultrasound-guided block of the saphenous nerve in the adductor canal. Regional Anaesthesia and Pain Medicine. 2009; 34:578–580
10. Ip HY, Abrishami A, Chung F. Predictors of postoperative pain and analgesic consumption: a qualitative systematic review. Anesthesiology. 2009; 111(3(:657-77.
11. Society KK. Guidelines for the management of postoperative pain after total knee arthroplasty. Knee surgery & related research. 2012 ;24(4(:201-207
12. Mai K. Abdallah, Mohamad G, Sohair MS, Ahmed A. Comparative Study between Adductor Canal Block and Femoral Nerve Block for Postoperative Analgesia in Knee Arthroscopy. The Medical Journal of Cairo University. 2018; 86:667-73
13. Liu SS, Ngeow J, John RS. Evidence basis for ultrasound-guided block characteristics: onset, quality, and duration. Regional anesthesia and pain medicine. 2010;35(2 Suppl):S26-35. Epub 2010/03/23.
14. Jæger P, Nielsen ZJ, Hilsted KL, Mathiesen O, Dahl JB. Adductor canal block versus femoral nerve block and quadriceps strength: a randomized, double-blind, placebo-controlled, crossover study in healthy volunteers. Anesthesiology. 2013; 118(2(:409-15
15. EF-Feky, UI AK, AM I. Comparative Study between Ultra-Sound Guided Femoral Nerve Block and Adductor Canal Block in Postoperative Analgesia after Knee Arthroscopy. The Egyptian Journal of Hospital Medicine. 2018; 72(3(:4179-84.

16. Hanson NA, Allen CJ, Hostetter LS, Nagy R, Derby RE, Slee AE, Arslan A, Auyong DB. Continuous ultrasound-guided adductor canal block for total knee arthroplasty: a randomized, double-blind trial. Anesthesia & Analgesia. 2014; 118(6(:1370-7
17. Kayupov E, Okroj K, Young AC, Moric M, Luchetti TJ, Zisman G, Buvanendran A, Gerlinger TL, Della Valle CJ. Continuous adductor canal blocks provide superior ambulation and pain control compared to epidural analgesia for primary knee arthroplasty: a randomized, controlled trial. The Journal of arthroplasty. 2018; 33(4(:1040-4
18. Alsheikh K, Alkhelaifi A, Alharbi M, Alhabradi F, Alzahrani F, Alsalim A, et al. Adductor canal blockade versus continuous epidural analgesia after total knee joint replacement: A retrospective cohort study. saudi journal of anaesthesia. 2020;14(1):38-43.
19. Shanthanna H, Huilgol M, Manivackam VK, Maniar A. Comparative study of ultrasound-guided continuous femoral nerve blockade with continuous epidural analgesia for pain relief following total knee replacement. Indian Journal of Anaesthesia. 2012;56(3):270.
20. Hegazy N, Sultan S. Comparison between effects of adductor canal block and femoral nerve block on early postoperative course in total knee arthroplasty: A prospective double-blind, randomized controlled study. Ain-Shams Journal of Anesthesiology. 2015;8(1):124-8.
21. Memtsoudis SG, Yoo D, Stundner O, Danninger T, Ma Y, Poultsides L, et al. Subsartorial adductor canal vs femoral nerve block for analgesia after total knee replacement. International Orthopaedics. 2015;39(4):673-80.
22. Armanious SH, Botros JM, El Ganzoury IM, Abdelhameed GA. Adductor canal block versus femoral nerve block in unicompartmental knee arthroplasty: a randomized, double blind, prospective, comparative study. Ain-Shams Journal of Anesthesiology. 2020;12(1):28.
23. Abdallah FW, Whelan DB, Chan VW, Prasad GA, Endersby RV, Theodoropolous J, Oldfield S, Oh J, Brull R. Adductor canal block provides noninferior analgesia and superior quadriceps strength compared with femoral nerve block in anterior cruciate ligament reconstruction. Anesthesiology. 2016; 124(5(:1053-64
24. Lund J, Jenstrup MT, Jaeger P, Sørensen AM, Dahl JB. Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results. Acta anaesthesiologica Scandinavica. 2011;55(1):14-9. Epub 2010/11/03.
25. Koh IJ, Choi YJ, Kim MS, Koh HJ, Kang MS, In Y. Femoral nerve block versus adductor canal block for analgesia after total knee arthroplasty. Knee surgery & related research. 2017; 29(2(:87-95
26. Tan Z, Kang P, Pei F, Shen B, Zhou Z, Yang J. A comparison of adductor canal block and femoral nerve block after total-knee arthroplasty regarding analgesic effect, effectiveness of early rehabilitation, and lateral knee pain relief in the early stage. Medicine. 2018;97(48):133-91.
27. Kozian A. Epidural analgesia compared with femoral nerve block for post operative pain therapy after total knee arthroplasty–a matched pair analysis. journal of anaesthesia and surgry. 2019;20(12):150-60.
28. Park S-J, Shim SY, Park SG. A comparison of continuous femoral nerve block combined with sciatic nerve block and epidural analgesia for postoperative pain management after total knee replacement. Anesthesia Pain Medicine. 2017;12(2):176-82.
29. Dauri M, Polzoni M, Servetti S, Coniglione F, Mariani P, Sabato AF. Comparison of epidural, continuous femoral block and intraarticular analgesia after anterior cruciate ligament reconstruction. Acta Anaesthesiologica Scandinavica. 2003; 47(1(:20-25
30. Vishwanatha S, Kalappa S. Continuous femoral nerve blockade versus epidural analgesia for postoperative pain relief in knee surgeries: A randomized controlled study. Anesthesia, essays researches. 2017;11(3):599.
31. Arjun BK, Prijith RS, Sreeraghu GM, Narendrababu MC. Ultrasound-guided popliteal sciatic and adductor canal block for below-knee surgeries in high-risk patients. Indian journal of anaesthesia. 2019; 63(8(:635-639