Research Article

Comparison of Two Different Concentrations and Volume of Ropivacaine for Continuous Bilateral Adductor Canal Block for Post-operative Analgesia in Primary Total Knee Arthroplasty.

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ABSTRACT

Total knee arthroplasty (TKA) is associated with varying degree of pain. Using peripheral nerve block after total knee arthroplasty, without impeding mobility, is challenging. Optimal concentration of Ropivacaine for bilateral continuous adductor canal block (ACB) after bilateral total knee arthroplasty is currently unknown during postoperative analgesia. The aim of the study is to compare two different concentrations of Ropivacaine in equianalgesic doses for ultrasound guided continuous adductor canal block for pain management after bilateral total knee arthroplasty. A prospective, double blind, randomized comparative study having ASA 1-3 grades, between 40 to 80 years, 100 patients received ACB of either Ropivacaine 0.1% or 0.2% in equianalgesic doses for 48 hrs after bilateral TKA. We assessed numerical rating scale (NRS) for pain at rest and 45-degree range of motion (ROM) as primary end point, motor power of quadriceps and fentanyl consumption as secondary end point and compared using Mann Whitney test. All patients had received comprehensive multimodal analgesia. Statistical analysis was done by using the SPSS software 22.0. The comparison was made using the Chi square test, unpaired T test and Mann Whitney test. NRS scores at rest and 45-degree ROM were statistically significant decreased in group-A receiving Ropivacaine 0.2% ($p < 0.004$ and $p < 0.001$). Motor power was higher in group-A ($p<0.001$) and fentanyl consumption was less in group-A ($p<0.001$). Ropivacaine 0.2% in equianalgesic dose provides more effective analgesia, preserve quadriceps strength and decreased fentanyl consumption than Ropivacaine 0.1% during first 48 hours for continuous bilateral ACB after primary bilateral total knee arthroplasty.

Keywords: Adductor Canal Block, mMRC, NRS, Ropivacaine.

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INTRODUCTION

The total knee arthroplasty (TKA) is a highly successful procedure for treating patients with advanced osteoarthritis (OA).[1] The number of knee replacement surgeries increased over the past decade and is projected to increase 6-fold from 2005 to 2030 because of the aging population.[2] Severe acute postoperative pain may interfere with patient's ability to sleep, walk and participate in rehabilitation activities.[3]

It is important to preserve quadriceps strength in immediate postoperative period, leading to early mobilization after surgery and enhancing functional recovery. Recently, adductor canal blocks (ACB) and periarticular infiltrations have become popular because they are able to preserve quadriceps strength while providing similar postoperative analgesia to the traditional femoral nerve block (FNB).[3-6] One drawback to ACBs is that they do not provide analgesia to the posterior knee. Single injection PAIs performed at the end of surgery can have a shorter duration of analgesia.[7] Although continuous infusions prolong postoperative pain relief; the potential risk of joint infections caused by the catheter used to administer the infusion is an impediment to its popularity.[8]

The aim of study was to compare two different concentrations of Ropivacaine in equianalgesic doses for ultrasound guided continuous adductor canal block for pain management after bilateral total knee arthroplasty.

The primary objective was to compare NRS at rest and 45-degree range of motion at 12, 24, 36 and 48 hrs in both groups. Secondary objective was to compare quadriceps strength in both groups and to compare opioid consumption as rescue analgesia among both the groups.

MATERIALS AND METHODS

The study design was a parallel double blind randomized controlled trial with allocation ratio of 1:1. No changes were made in the study methodology after trial commencement.

Approval from Institutional Research Review Committee and Ethics committees were taken prior to the

commencement of the study wide letter no. Ref ISIC/RP/2015/053.

Recruitment was started in August 2016 and ended in March 2017.

The eligibility criteria of the participants included in the study were patients posted in operation theatre for bilateral total knee arthroplasty under combined spinal and epidural anesthesia within the age group from 40 years to 80 years and ASA grade one to three.

Exclusion criteria were patients who had inability to cooperate, no consent, allergy to local anesthetics, any bleeding disorder, neuropathy of any etiology in the affected extremity, medicine (chronic opioid >1 month of 60mg morphine oral equivalent daily) or alcohol abuse, infection over injection site, language barrier, psychiatric illness, hepatic or renal failure, patients under general anesthesia and basal metabolic index >40.

The study was conducted in the operation theatre of tertiary level spine and orthopedic institute.

Sample size was calculated using epi info 7 software a two-sided alpha error rate of 0.05 with a statistical power of 80% to detect a minimally important difference between two groups. This required approximately 50 patients to each group. Therefore, we chose to recruit 100 patients for the trial, 50 to each group.

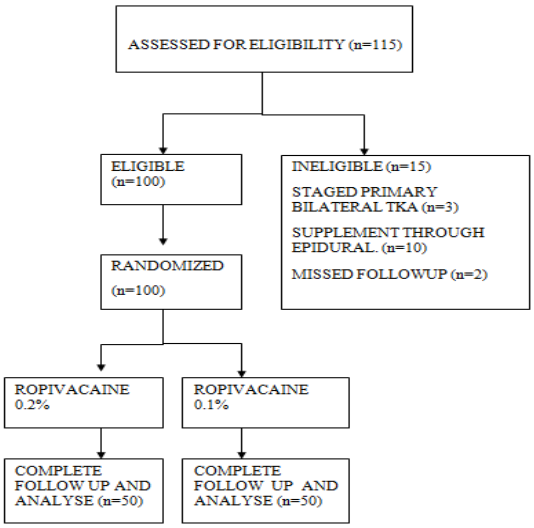

Figure 1: Participant flow through Chart

Randomization was achieved via block randomization prior to their bilateral TKA. The randomization consists of **Group- A** (0.2% Ropivacaine at 3ml) and **Group- B** (0.1% Ropivacaine at 6ml).

An independent anesthesiologist, who was not involved in the study or conducting outcomes assessments, prepared and concealed the study drugs from the outcome assessors and the anesthesiologists responsible for performing the motor sparing blocks, and the orthopedic surgeons performing the infiltrations. Therefore, the patient, surgeon, block anesthesiologist, and outcome assessor all remained blinded. Group A block solution and Group B block solution are visually indistinguishable. Furthermore, the containers were identical in appearance.

The ACB was performed under ultrasound guidance (SonoSite Inc., Bothell, WA, USA), a linear US probe with 18-gauge Contiplex Tuohy needle with 10ml of 0.2%ropivacaine. A 20-gauge peripheral nerve block catheter was advanced 12-15 cm beyond the tip of the needle. The position of the catheter tip was adjusted during injection to obtain a semicircular expansion between the Sartorius fascia and the artery and catheter is fixed with suture. Catheter attached to elastomeric infusion pump which consist of 0.2% Ropivacaine at 3ml (**Group A)** and 0.1% Ropivacaine at 6ml **(Group B)** in primary bilateral adductor canal. Postoperatively, all patients received i.v paracetamol 1 gm 8 hourly and i.v diclofenac 75 mg 12 hourly. Rescue analgesia consisted of patient control analgesia of i.v. fentanyl 15 microgram demand dose with lockout interval 15min as needed if pain was still poorly controlled. All patients were analyzed at 12, 24, 36 and 48 hrs in postoperative period to measure NRS score for pain and mMRC (modified medical research council scale) for muscle strength.

These patients received periarticular infiltration of 100 ml solution which consist of local anesthetics 0.2% Ropivacaine 100mg, 0.5ml epinephrine, 100 microgram of fentanyl, 30 mg of ketorolac and 47ml normal saline of which half of solution infiltrated in one knee and remaining into another knee. The first 40 ml aliquot of the mixture was injected into the posterior aspect of the capsule and the medial and lateral collateral ligaments just prior to implantation of the component. Finally, the remaining 10 ml was infiltrate into the fat and subcuticular tissues.

The primary outcome in this study was comparison of NRS. The NRS is an 11-point interval scale from zero (no pain) to ten (worst pain imaginable). Williamson et al. indicated that the 11-point interval scaled NRS is reliable, valid with high sensitivity to change in pain.[9] Patients were assessed for pain during rest and activity (45 degrees of flexion) at baseline, upon arrival in post anesthesia care unit (PACU), and then at 12, 24, 36, and 48 hours.

The secondary outcome in this study was muscle strength. This was measured using a modified Medical Research Council Scale (mMRC). Tatjana Paternostro-Sluga et al indicated that the 5-point mMRC scale has substantial inter-rater and intra-rater reliability and strong validity and can be recommended for clinical use.[10] Patients were assessed for muscle strength at baseline, upon arrival in PACU, and then at 12, 24, 36, and 48 hours.

We recorded the total doses of rescue medication fentanyl was received during 12, 24, 36 and 48 hours.

Statistical analysis was done by using the SPSS software 22.0. The comparison was made using the Chi square test, unpaired T test and Mann Whitney test.

RESULTS AND DISCUSSION

115 patients were initially considered eligible for the study. Out of these, 15 patients were ineligible. 2 patients were missed to follow-up, thirteen patients were withdrawn after being randomized. 100 eligible patients gave their consent to participate in the study. They were randomized into two groups of fifty patients in each group and outcome was analyzed in 100 patients. The detailed participant flow diagram is in Figure 1.

The demographic parameter such as age was compared by Pearson's Chi-square test. The p value obtained was 0.808 which is more than α = 0.05. So, two groups had statistically similar mean age.

Table 1: Distribution of age.

Age	Group A	Group B	Total	Pearson's Chi-square	p- value
<55 Yrs	5	7	12	0.971	0.808
55-64 Yrs	18	17	35		
65-74 Yrs	23	20	43		
>75 Yrs	4	6	10		
Total	50	50	100		

Numeric rating scale score at rest. We analyzed NRS at rest in post-operative period after 12hrs, 24hrs, 36hrs, and 48hrs of the surgery. The p value of NRS in post-operative period at 12hrs is 0.87 which is not significant, at 24hrs 0.010, at 36hrs is 0.021 and at 48hrs is 0.004. The p value in post-operative period at 24, 36, and 48 is below α = 0.05 meaning that there is statistically significant difference in NRS scores of the both groups. NRS was higher in Group B. There was gradual decrease in NRS score in both groups with duration in post-operative period. The data has been given in Table 2 and Figure 2 operative period. The data has been given in Table 2 and Figure 2.

Table 2: Numeric rating scale score at rest. NS- Not Significant, S- Significant

	Group	N	Mean	SD	P value	Significance
NRS 12	A	50	2.34	0.601	0.087	NS
	B	50	2.50	0.614		
NRS 24	A	50	2.23	0.465	0.010	S
	B	50	2.46	0.513		
NRS 36	A	50	2.19	0.415	0.021	S
	B	50	2.40	0.515		
NRS 48	A	50	2.13	0.332	0.004	S
	B	50	2.37	0.482		

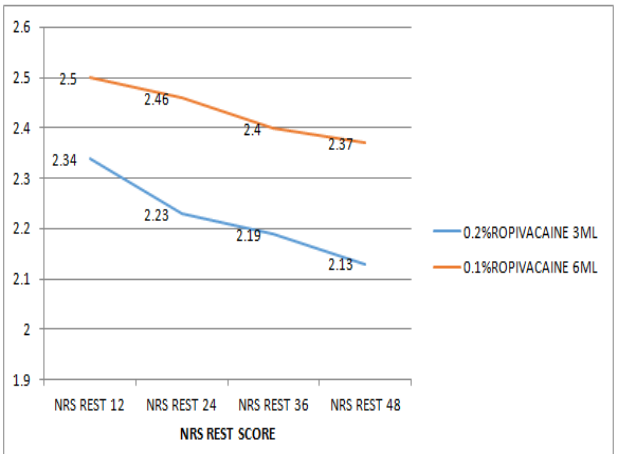

Figure 2: Numerical Rating Scale (NRS).

Numeric rating scale score at ROM 45. We analyzed the p value of NRS at ROM 45 degree in post-operative period was at 12, 24, 36 and 48hrs after surgery is 0.000, 0.000, 0.012 and 0.000 respectively is below α = 0.05 meaning that there is statistically significant difference in both groups. NRS was higher in Group B. There was gradual decrease in NRS score in both groups with duration in post-operative period.

The data has been given in Table No.3 and Figure No. 3.

The p value of mMRC in post-operative period is at 12, 24, 36 and 48hrs after surgery is 0.005, 0.000, 0.000 and 0.000 respectively is below α = 0.05 meaning that there is statistically significant difference in both groups. mMRC score was higher in Group A. There was gradual decrease in NRS score in both groups with duration in post-operative period. The data has been given in Table No.4 and Figure No. 4.

Table 3: Numeric rating scale score at ROM 45. NS- Not Significant, S-Significant

	Group	N	Mean	SD	P value	Significance
NRS 12	A	50	3.37	0.560	0.000	NS
	B	50	3.88	0.792		
NRS 24	A	50	3.23	0.465	0.000	S
	B	50	3.68	0.675		
NRS 36	A	50	3.19	0.483	0.012	S
	B	50	3.53	0.841		
NRS 48	A	50	3.05	0.465	0.000	S
	B	50	3.50	0.801		

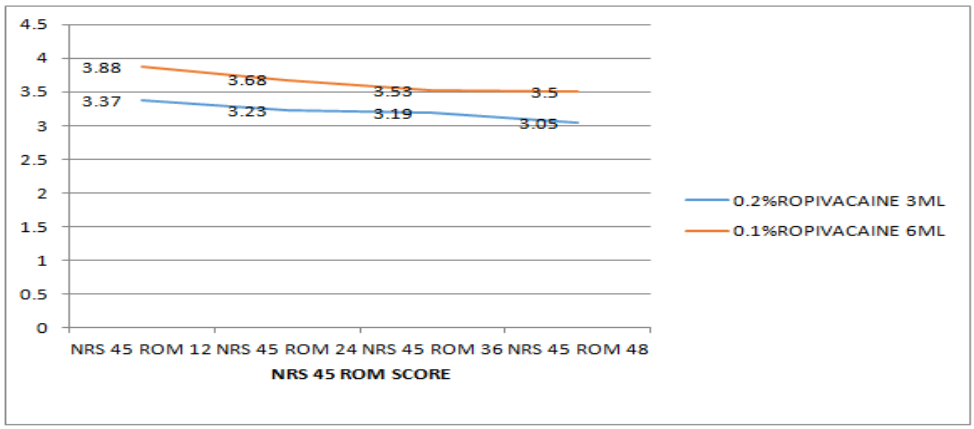

Figure: 3. Numerical rating pain scores at ROM 45 degree.

Table 4: mMRC score. NS- Not Significant, S-Significant.

	Group	N	Mean	SD	P value	Significance
mMRC 12	A	50	3.58	0.518	0.005	NS
	B	50	3.30	0.494		
mMRC 24	A	50	3.67	0.458	0.000	S
	B	50	3.33	0.458		
mMRC 36	A	50	3.74	0.419	0.000	S
	B	50	3.40	0.462		
mMRC 48	A	50	3.83	0.358	0.000	S
	B	50	3.42	0.477		

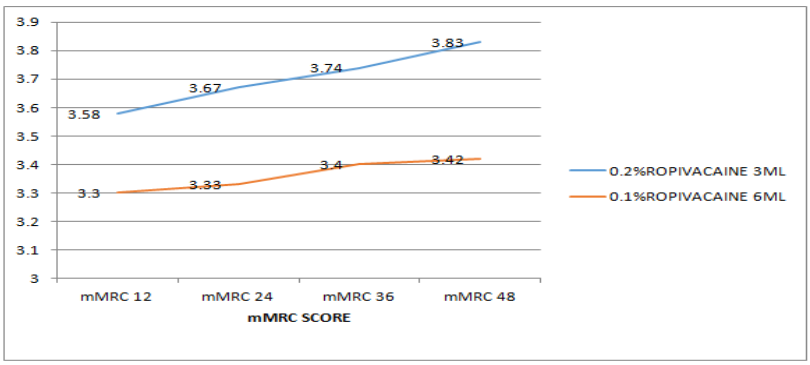

Figure 4: Modified medical research council scale score.

Fentanyl consumption analyzed in two groups, the p value at 12, 24, 36 and 48hrs after the surgery is 0.000 at all recording hours which is below α = 0.05 meaning that there is statistically significant difference in both groups. Need of fentanyl consumption was more in group B.

DISCUSSION

Total knee arthroplasty (TKA) is a successful intervention for patients with painful degenerative diseases affecting the knee joint. Since FNB targets the femoral nerve, which comprises both sensory and motor branches, it often weakens the quadriceps muscle, resulting in delayed mobilization and an increasing risk of falling.

Adductor canal block (ACB) is a relatively new type of peripheral nerve block technique introduced by Lund et al[11]. It offers better patient management after TKA than FNB. ACB affects not only the two largest sensory contributors from the femoral nerve to the knee, namely, the saphenous nerve and the branch to the vastus medialis, but also the articular branches of the obturator nerve. However, the block is distal to most of the efferent a branch to the quadriceps muscle and therefore largely preserves the strength of this muscle.

Most of the studies have compared Ropivacaine with saline or Bupivacaine in adductor canal block following bilateral TKA. Some have even compared adductor canal with femoral nerve blocks with these drugs. However, none of the studies have compared Ropivacaine in two different concentrations (0.1% and 0.2%) in bilateral TKA.

Ashraf Elazab et al[12] conducted meta-analysis on 10 randomized control trial in which 661 patients were enrolled comparing ACB with placebo or other anaesthetic technique. Meta-analysis showed that patients who received adductor canal block had significantly lower VAS score at rest and activity within 24 hrs. Postoperative compared to the patients who received placebo or FNB.

Neil et al[13] compared continuous adductor canal block with 0.2% Ropivacaine with saline for post-operative analgesia and found better pain scores with 0.2% Ropivacaine group. Similarly, U Grevstad et al[6] conducted randomized control trial on 50 patients either continuous ACB or placebo and had found decrease pain score during active flexion of knee in the patient group who received 0.2% Ropivacaine via ACB than patients who received saline (placebo).

In our study, we have compared Ropivacaine in adductor canal block in the concentration of 0.2% and 0.1% and dosage of 3ml and 6ml respectively for post-operative analgesia in two groups of the patients. We found the average NRS scores in both the groups at rest and ROM 45 was decreased after patients received adductor canal blocks, with mean NRS scores lower in the patients who received 0.2% Ropivacaine 3 ml and results were also statistically significant.

Sorensen et al[14] and Neil et al[13] randomized 64 and 80 patients respectively either ACB with Ropivacaine or placebo group and had found ACB with Ropivacaine improve quadriceps strength. Similarly, Elkassabany et al[15] randomized 60 patients and compared Ropivacaine with continuous ACB to continuous FNB and had found that muscle strength is higher on post-operative day 1 with continuous ACB group. The results of these studies are in accordance with our results i.e. a Ropivacaine ACB patients had better muscle power. Further comparing dosage and concentration of Ropivacaine (0.1% & 0.2%) we found the patients who received 0.2% Ropivacaine had better Quadriceps muscle strength.

Quadriceps muscle power was compared on modified medical research council scale (mMRC). In our study mMRC score in both groups was between 3 and 4. The mean mMRC score was higher in patients who received 0.2% Ropivacaine and it was also statistically significant. This could be due to better pain control with 0.2%ropivacaine in these patients, where as decrease quadriceps muscle strength in 0.1% Ropivacaine group could be due to proximal spread to femoral triangle along with higher mean pain scores.

Fentanyl was used as rescue analgesia in intravenous patient-controlled mode with demand dose of 15mcg in both groups. The overall consumption of fentanyl was less with the group who received 0.2% Ropivacaine and it was statistically highly significant with p value of 0.000. This can be explained due to lower pain scores and better pain control with 0.2% Ropivacaine.

Till date no study has been done comparing Ropivacaine 0.1% and 0.2% in bilateral TKA via adductor canal block for post-operative analgesia. So, we have compared our results with studies available on TKA for post-operative analgesia with different techniques (e.g. FNB, unilateral ACB) and with different drugs (saline and bupivacaine) and results have been shown that marked NRS score reduction was found with 0.2% Ropivacaine in adductor canal block.

CONCLUSION

It has been already proven in various studies that continuous adductor canal block are superior to continuous femoral nerve block in promoting early ambulation after TKA but in our study we have proved that 0.2% Ropivacaine in low volume are gives better analgesia and preserve quadriceps muscle strength with decreased opioid consumption as compare to 0.1% Ropivacaine in high volume.

Hence it can be concluded that 0.2% Ropivacaine (3ml) used for post-operative analgesia in bilateral TKA via adductor canal block is better in terms of pain scores, muscle strength and consumption of fentanyl than 0.1% Ropivacaine.

Limitation of our study is objective criteria for pain assessment and muscle strength. Evaluation of quantitative assessment of quadriceps strength as during qualitative assessment when patient asked to extend knee to evaluate motor power of quadriceps, patient try to utilize accessory muscle which could lead to false positive assessment of quadriceps strength.

Future direction needs a further study with large sample size.

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