The effects of addition of dexamethasone to bupivacaine during ultrasound-guided femoral nerve block for postoperative analgesia in patients undergoing total knee replacement surgery

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Received 08 November 2017
Accepted 26 December 2017

Journal of Current Medical Research and Practice
January-April 2018, 3:47–51

Introduction
The goal of knee replacement is to relieve pain, improve quality of life, and maintain or improve knee function. The procedure is performed on people of all ages. However, a significant number of patients experience persistent pain and functional limitations following knee replacement, with ~20% of patients reporting unfavorable pain outcomes.

Materials and methods
Our study was done after obtaining Assiut University Hospital Ethical Committee approval and informed written consent from the patients who were admitted to the Department of Orthopedics in Assiut University Hospital and were planned for total knee replacement surgery in the period from December 2015 until July 2017. Our study included 60 patients aged between 18 and 80 years. Patients were randomized into two groups: group B (30 ml of 0.25% bupivacaine) and group BD (28 ml of 0.25% bupivacaine + 2 ml dexamethasone 8 mg).

Results
The current study showed that preemptive addition of 8 mg dexamethasone to 30 ml bupivacaine 0.25% for femoral nerve block guided with ultrasound for total knee replacement surgery on side of operation resulted in a reduction of visual analog scale pain score over the postoperative 24 h prolonged the duration of the block, required longer time till first analgesic, and led to more patient satisfaction and less incidence of nausea and vomiting. As seen in our results that the visual analog scale was significantly low starting from 4 h (1 ± 0 vs. 1.13 ± 0.35; $P < 0.001$), 8 h (1.07 ± 0.25 vs. 1.67 ± 0.71; $P < 0.001$), 12 h (1.23 ± 0.43 vs. 1.97 ± 0.67; $P = 0.789$), 16 h (1.67 ± 0.71 vs. 2.37 ± 0.67; $P = 0.563$), 20 h (1.9 ± 0.76 vs. 2.87 ± 0.82; $P = 0.774$), and 24 h (2.03 ± 0.76 vs. 2.97 ± 0.61; $P = 0.052$).

Conclusion
Our study results demonstrate that the addition of dexamethasone to bupivacaine suggestively prolongs its analgesic effect postoperatively. These results are consistent with the trend of previous studies using dexamethasone as an additive to local anesthetic in peripheral nerve blocking.

Keywords:
dexamethasone, pain, total knee arthroplasty, ultrasound, visual analog scale

J Curr Med Res Pract 3:47–51

2357-0121

Introduction

The number of total knee arthroplasty procedures performed is increasing dramatically. Projections suggest that the same trend will continue over the next decades, resulting in a demand of 3.48 million total knee arthroplasties in 2030 [1].

Pain following total knee replacement surgery is unbearable, and it is the most common complication after the surgery and the most common complaint received from the patients who undergo total knee replacement surgery.

Appropriate pain treatment protocols are needed to reduce postoperative morbidity, improve the results of the surgery, and decrease hospital costs. Adequate postoperative pain relief is associated with positive long-term effects for patients such as reduced postoperative cognitive changes, better quality of life, and reduced risk of chronic or persistent postoperative pain [2].

The management of postoperative pain has improved over the past decade owing to more informed clinicians, and enhanced pain management modalities (epidural, intrathecal, and patient-controlled analgesia), as well as the use of a multimodal approach (NSAIDs, acetaminophen, opioids, and regional analgesia).

Despite these advancements, inadequate pain control persists.

Femoral nerve block (FNB) in combination with oral and parenteral analgesia has been used to provide effective postsurgical analgesia. FNB has been generally described as safe and effective, and single-shot FNB has been shown to improve analgesia and reduce morphine requirements postoperatively [3].

Dexamethasone added to local anesthetics (LAs) appears to prolong single-injection nerve block. The analgesic effects of spinal and systemic corticosteroids combined with LAs have proven to be effective in humans, whereas dexamethasone microspheres have increased block duration [4].

A meta-analysis regarding a combination of dexamethasone and LA solution in peripheral nerve blocks (PNBs) has demonstrated that perineural dexamethasone decreased postoperative pain and prolonged the duration of LA PNBs [5].

Materials and methods

After obtaining Assuit University Hospital Ethical Committee approval and informed written consent from the patients admitted in Assuit University Hospital, our study included 60 patients. Patients were randomized into two groups: group B (30 ml of 0.25% bupivacaine) and group BD (28 ml of 0.25% bupivacaine + 2 ml dexamethasone 8 mg). Preoperative investigations including blood cell count, coagulation profile, liver function tests, kidney function tests, fasting blood sugar, and ECG.

Spinal anesthesia was performed in all patients in groups B and BD, in the sitting position after skin antisepsis with chlorhexidine, sterile surgical field placement, and infiltration of 1% lidocaine in the skin and into the intervertebral space selected (L3-L4, L4-L5, or L5-S1). Disposable Quincke-type cutting needle (25 G) was used. The subarachnoid space was identified by spontaneous reflux of cerebrospinal fluid, followed by 2.5 ml of 0.5% hyperbaric bupivacaine. Patients were immediately placed in the supine position without tilting the operating table. Anesthesia was considered satisfactory when there was loss of cold sensitivity from lower limbs to the umbilicus, tested with an alcohol swab.

Technique of ultrasound-guided femoral nerve block

The ultrasound-guided technique of FNB differs from nerve stimulator or landmark-based techniques in several important aspects. Ultrasound application allows the practitioner to monitor the spread of LA and needle placement and make appropriate adjustments, should the initial spread be deemed inadequate. Moreover, because of the proximity of the relatively large femoral artery, ultrasound may reduce the risk of arterial puncture, which often occurs with this block with the use of nonultrasound techniques. Palpating the femoral pulse as a landmark for the block is not required with ultrasound guidance, a process that can be challenging in obese patients. Although the ability to visualize the needle and the relevant anatomy with ultrasound guidance renders nerve stimulation optional, and motor response obtained during nerve stimulation often provides contributory information.

Numerical visual analog scale (VAS) was used to assess pain intensity in patients who received FNB.

Follow-up of the patient is done for 24 h, and every 4 h, the patient was asked by the anesthetist if he/she can specify which part of the knee hurts more either anteriorly (femoral nerve) posteriorly (sciatic nerve) to detect the effects of the sciatic nerve not included in our block. Moreover, the pain is assessed by numerical VAS.

Statistical analysis

Data were collected and analyzed by computer program SPSS version 23 (SPSS Inc., Chicago, Illinois, USA). Data were expressed as mean, SD, number, and percentage. Mann–Whitney test was used to determine significant for numeric variable. χ^2 was used to determine significance for categorical variable. Person's correlation was used for correlations between groups.

Results

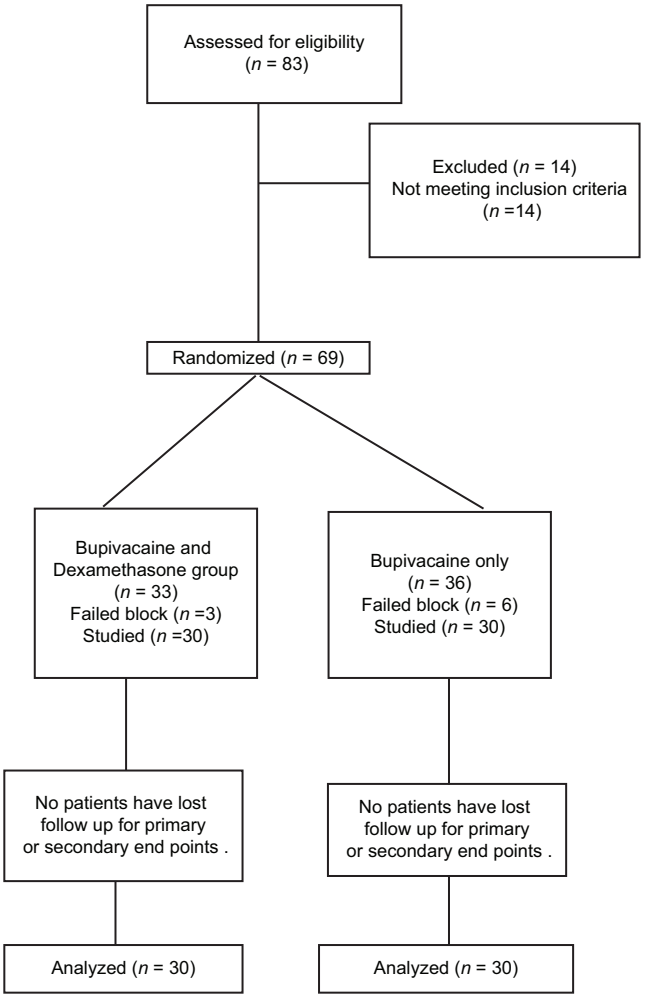
Regarding patient hemodynamics, systolic blood pressure, diastolic blood pressure, and heart rate at different intervals showed no statistical difference between both the groups. Moreover, hemodynamics was not much affected, except for the first 4 h, where the hemodynamics was affected to some extent owing to spinal anesthesia, as shown in Tables 1 and 2.

Fig. 1 presents the allocation process according to the CONSORT statement. As seen from the diagram,

Table 1 Demographic data in the study groups

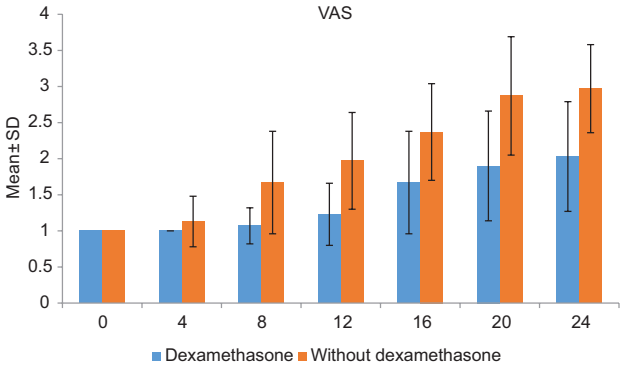
	Dexamethasone [*n* (%)]	Without dexamethasone [*n* (%)]	*P*
Sex			
Male	11 (36.7)	9 (30.0)	0.584
Female	19 (63.3)	21 (70.0)	

Figure 1



Consort study diagram.

Figure 2



Difference in VAS between the two groups in 24 hours.

Table 2 Hemodynamic data in the study groups

Time	Dexamethasone (mean±SD)	Without dexamethasone (mean±SD)	*P*
0 h			
SBP	129.37±21.09	139.67±12.17	0.003*
DBP	72.67±16.39	79±11.85	0.005*
HR	76.7±11.37	84.13±12.6	0.771
4 h			
SBP	110.5±16.78	109.83±13.99	0.106
DBP	65±15.7	59.67±14.97	0.560
HR	74.73±9.05	77.33±13.31	0.003*
8 h			
SBP	115±19.87	120.83±15.49	0.063
DBP	63.67±17.9	66±15.67	0.537
HR	70.83±8.52	79.67±14.26	0.008*
12 h			
SBP	122.83±19.9	131.33±15.86	0.127
DBP	68.33±14.16	76.67±15.83	0.415
HR	73.4±9.36	82.17±8.87	0.879
16 h			
SBP	127.5±19.46	135.5±14.64	0.016
DBP	70±19.12	78.33±12.06	0.002*
HR	78.33±9.32	84.33±7.63	0.012
20 h			
SBP	132.83±17.5	143±13.87	0.025
DBP	76±13.03	81.67±13.67	0.855
HR	83.33±7.81	85.83±8.91	0.832
24 h			
SBP	131.17±21.2	141±13.48	<0.001**
DBP	73.5±20.18	80±11.14	<0.001**
HR	80.47±11.5	84.17±6.83	<0.001**

*Significant, **Highly significant. DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure.

there were 83 patients included in the study. A total of 14 patients did not meet the inclusion criteria and were excluded. In the remaining 69 patients, the block failed in three patients in the dexamethasone group and six patients in the bupivacaine-only group.

As seen from the previous data, we can see that the VAS scores are slightly lower in the dexamethasone group from 0 to 12 h, but significantly lower VAS scores in the dexamethasone group than the other group can be seen in 24 h (Fig. 2).

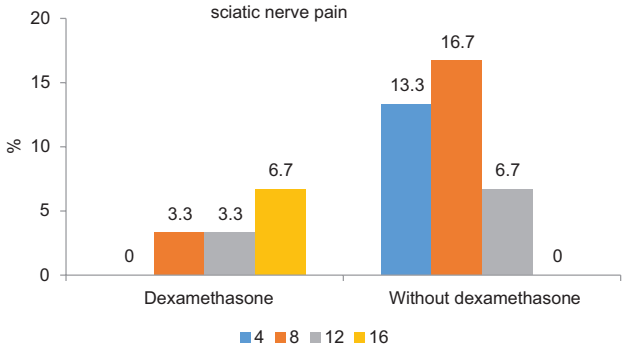
Another component that should be considered while analyzing the study data is the pain felt in the back of the patient's knee, which is originating from the sciatic nerve supplying this region: at 4 h (0 vs. 4; $P = 0.038$), at 8 h (1 vs. 5; $P = 0.085$), at 12 h (1 vs. 2; $P = 0.554$), and at 16 h (2 vs. 0; $P = 0.15$) (Fig. 3).

Discussion

There are several theories to explain this effect of dexamethasone. First is the degree of vasoconstriction produced by steroids, and this in turn decreases the absorption of LAs. Second, theory indicates that dexamethasone increases the inhibitory activity of potassium channels on pain sensory nerves. Another theory refers to anti-inflammatory action of dexamethasone and blocking transmission of nociceptive C-fibers [6].

Regarding patient hemodynamics, systolic blood pressure, diastolic blood pressure, and heart rate at

Figure 3



Difference between the pain of sciatic nerve origin between the two groups.

different intervals showed no statistical difference between both the groups. Moreover, hemodynamics was not much affected, except for the first 4 h, where the hemodynamics was affected to some extent owing to spinal anesthesia.

The current study showed that preemptive addition of 8 mg dexamethasone to 20 ml bupivacaine 0.5% for FNB guided with ultrasound for total knee replacement surgery on side of operation resulted in reduction of VAS pain score (the significant difference appeared at 24 h after the block), longer time till first anelgesic requirement, more patients satisfaction, less incidence of nausea and vomiting, and early ambulation.

The quality of the pain control was superior in dexamethasone group, which is consistent with a multimodal analgesia effect [7].

Dexamethasone has not been tested with higher doses, and it remains possible that the use of higher dexamethasone doses would result in a more sustained reduction in opioid consumption.

In the current study, no LA toxicity, no hematoma, or excessive tissue trauma developed at the site of injection in both group. This result could probably be owing to the guidance of ultrasonography that enabled better visualization of the femoral triangle before injection.

Various adjuvants like opioids, α-2 agonists, ketamine, and many more drugs have been mixed with LAs for PNBs. These drugs usually hasten the onset of action and prolong the duration of analgesia. They may also allow for a reduction in the total dose of LA used and related adverse effects. Use of PNBs as an alternative to general anesthesia has become a part of standard anesthesia care. The interest in PNBs has increased during the last decade owing to the availability of better needles, catheters, and ultrasonography. A single dose of LA has a limited duration of action, hence various adjuvants are added to improve the quality of anesthesia and prolong the duration of analgesia.

Dexamethasone added to LAs appears to prolong single-injection nerve block. The analgesic effects of spinal and systemic corticosteroids combined with LAs have proven to be effective in humans, whereas dexamethasone microspheres have increased block duration [4].

Our study results demonstrate that the addition of dexamethasone to bupivacaine suggestively prolongs its analgesic effect postoperatively. These results are consistent with the trend of previous studies using dexamethasone as an additive to LA in PNB [8,9].

Regarding the safety profile of dexamethasone, the results are promising. None of our study patient complained of neurotoxicity or presented with any other complaints attributable to dexamethasone, although our sample size was insufficient to detect rare effects, and we did not follow our patients beyond 48 h. There are safety concerns regarding the perineural use of dexamethasone. The neurological risk, if any, of dexamethasone thus appears to be small [10].

Woo *et al.* [11] suggested that dexamethasone demonstrated significant beneficial dose-dependent effects (>5 mg) on duration to the first analgesic request, the number of patients not requiring analgesics, and analgesic use within the first 48 h after interscalene block for arthroscopic shoulder surgery. There were no significant effects on pain scores or incidence of adverse effects [11].

Vardhan *et al.* [12] stated that addition of dexamethasone to LA drugs in supraclavicular brachial plexus block significantly prolongs the duration of analgesia and duration of motor block in patients undergoing upper limb surgeries.

Conclusion

In this study, we took into our consideration the origin of pain in the knee region, as the knee is supplied anteriorly by the femoral nerve whereas posteriorly by the sciatic nerve. Regarding that, we noted the effect of the sciatic nerve contributing to the pain originating from the knee region, and we found that 15 of 60 patient felt the pain in the back of the knee first and the complaint started by pain in the back of the knee only, and that may have affected the study results, but notably, this pain was relieved dramatically after receiving paracetamol 1 g.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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