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Femoral 3-in-1 Nerve Block for Total Knee Replacement, an Analgesic Approach Not to Be Neglected. Single Center Experience and Literature Review

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Abstract

Objectives. Total Knee Replacement Surgery (TKR) is one of the most common elective orthopedic operations. Postoperative pain after total knee replacement, remains a challenge. In this retrospective observational study, we evaluated the effectiveness of 3-in-1 nerve block in patients after total knee arthroplasty compared to standard opioid treatment, and we state the reasons why this approach should still be considered. **Methods.** To evaluate the effectiveness of the 3-in-1 nerve block, we assessed the acute pain service archive and compared the values of the visual analog scale, by separating patients into two groups according to the analgesic regimen they received as per local protocols. In group A, patients received 0.25% bupivacaine through a 3 in 1 block catheter and additional meperidine IM if needed, while in group B they received meperidine every six hours. **Results.** Our analysis showed the statistically significant better effectiveness of 3-in-1 nerve block with bupivacaine administration in postoperative TKR pain control compared to repeated administration of meperidine. **Conclusion.** The results of our study suggest that 3-in-1 nerve block with bupivacaine is an option that must always be considered in order to alleviate post-operative pain after TKR.

Key Words: Postoperative Pain ▪ 3-in-1 Nerve Block ▪ Femoral Nerve Block ▪ Total Knee Replacement.

Introduction

Steadily increasing life expectancy makes the greater part of the population susceptible to degenerative diseases, with osteoarthritis being one of the most common (1). Due to both obesity and trauma, lower limbs are commonly affected, with an incidence of 41% in the knee and 19% in the hips. Several studies have shown that knee osteoarthritis severely affects the quality of life, causing physical disability and increased mortality. Thankfully, when this condition cannot be managed with conservative approaches, total knee replacement (TKR) surgery has become the 'salvation' treatment (2). TKR is currently a routinely performed operation of medium morbidity and low mortality because of the advanced surgical approaches used, the improved quality of materials, and the enhanced anesthesiology strategies deployed (3). However, management of postoperative pain after total knee replacement still remains a challenge. Sixty percent of these patients have severe postoperative pain and 30% refer to moderate levels of postoperative pain (4).

Insufficient postoperative analgesia has a strong negative impact on patients' health by increasing the risk of cardiovascular incidents, while impeding early mobilization of the knee. Delayed or reduced mobilization carries the imminent consequences of dysfunction, ligament contractions and muscle atrophy, which may retard or in the worst cases, hinder the restitution of the knee function.

In order to prevent this, the majority of postoperative programs for remobilization start within the first 24 hours, or in some cases immediately after the operation (PACU), and include physiotherapy and application of continuous passive mobilization (5). Despite the development of a wide spectrum of rehabilitation protocols the main obstacle for their application is pain. Several analgesic techniques have been tested over the years to alleviate pain sufficiently. None of them has yet proven superior enough to become a gold standard (6). So, in many centers, including ours, traditional, well-established, scientifically recommended and effective approaches are still used.

In this study, we aimed to evaluate the current role of the femoral "3 in 1" nerve block with a catheter, in patients who had undergone TKR.

Methods

Study Design and Population

The study was conducted at the University Hospital of Heraklion by analyzing data acquired in the first semester of 2015. As it is a retrospective study assessing acute pain service from medical records no approval was required from our institutional review board. According to local protocols, patients receive either opioids systemically, or a neural block is performed in order to achieve postoperative analgesia. The regimen that is selected each time depends on both the patient's and the anesthetist's preferences. In this retrospective observational study, we included 42 patients who underwent total knee replacement under spinal anesthesia, and had similar demographics, minor or no comorbidities, an ASA physical status score of 1-2, and aged between 50 and 79 years old. Patients with severe comorbidities or patients that received other analgesic regimens (multiple opioids, analgesic adjuvants) or perioperative sedation were excluded from the analysis. In order to minimize bias attributed to surgical technique-induced pain, we only included patients operated by the same surgeon. Analysis was performed by allocating patients to two groups on the basis of the postoperative analgesic approach they received, which was jointly decided after discussion between the patient and the anesthetist. In group A, patients had a femoral 3-in-1 block with a catheter in place, and pain was alleviated with repeated boluses of local anaesthetic with opioids as rescue therapy, while in group B (control) the pain was managed with administration of opioids in regular divided doses.

Implementation Process

According to local protocols, Group A was treated with repeated doses of 40ml bupivacaine 0.25% via a "3-in-1 catheter" and additionally meperidine 50 mg (IM) as a rescue analgesic if no adequate pain control was achieved with bupivacaine alone. In group B repeated meperidine boluses of 50mg (IM) were given every 6 hours.

To perform the "3-in-1" block, there is a standardized approach in our department that is applied to all patients in the same way. Specifically, patients were seated in a comfortable position and their leg was rotated 15 degrees outwards. The inguinal area was sterilized and local infiltration of the area with 3 ml lignocaine 2% was performed. Then a 9.5 G (pajunk) needle was inserted, 2.5 cm inferior of the inguinal ligament and 1.0 cm lateral of the femoral artery. The femoral nerve was located with the use of a nerve stimulator (stimuplex S Braun). The exact point was identified where contraction of the quadriceps muscle was achieved with the lowest intensity of stimulus (current of 0.5 mA in 0.1 ms). Then, with a modified seldinger technique (catheter-through the needle) the catheter (pajunk-plexolong) was advanced for a distance of about 10cm into the neural sheath. After verification of the position of the catheter, with no blood to be aspirated, an antibacterial filter was connected. After this, 40 ml of 0.25% bupivacaine were injected, prior to initiation of anesthesia. All patients received spinal anaesthesia, with hyperbaric bupivacaine 0.5% w/v at L3 - L4 or L4 - L5 at a dose of approximately 12 mg depending on the

patient's height, and one dose of Tenoxicam 20 mg IV was administered.

Data Collection

We assessed the acute pain service archive in order to retrieve data for patients who fulfilled the criteria mentioned above according to their preoperative assessment sheet and intraoperative diagram. Records included pain scores from PACU (1st hour), 6 and 9 hours postoperatively, and thereafter every 12 hours until 72 hours postoperatively, with the use of the 100mm Visual Analogue Scale (VAS). Furthermore, the time when the patient was able to walk was noted. Other vital parameters were also recorded (Ramsay score, heart rate, respiratory rate, blood pressure - Data not shown). The total dose of meperidine administered IM (in both groups) was calculated. Side effects related to analgesia were also noted in the records (nausea, vomiting, intestinal paralysis, respiratory depression).

Statistical Analysis

Data were analyzed with SPSS Version 23 statistical software. We performed an unpaired t-test to compare meperdine dose and boluses, as assumptions were satisfied, and a Chi-Square test for sex. Finally we used the Mann-Whitney U test for VAS Scores and the rest of the variables. A two-sided significance level of P=0.05 was used for all tests.

Results

Forty-two patients, 15 men and 27 women, median age 67.25, were analyzed in the study. There were no significant differences regarding the patients' demographics between the two groups. Group B patients needed a significantly higher mean total dose of meperidine: Group A = 12.5 mg vs. Group B = 520 mg. Thus, the majority of patients in the study group were sufficiently covered by the 3 in 1 block alone, with no need for extra analgesics. Only three patients in the study group needed additional meperidine. As far as the length of hospital stay is concerned, it was prolonged by almost a day in group B (control), further increasing the costs. Another parameter evaluated was 'Days to Walk', which refers to the period from the surgical procedure to the moment that the patient was able to stand up with minor support and walk a distance of a few meters. We noticed that this period was significantly reduced in Group A, by almost a day (P<0.05), making the patient independent earlier, as well as further diminishing problems related to prolonged bed stay (Table 1).

Regarding the intensity of pain, VAS scores both at rest and during movement were significantly lower in group A in comparison to group B, except for the values at 48h where no statistical significance was shown (Tables 2 and 3).

There were no significant variations in the vital parameters and no opioid side effects were reported in either patient group.

Table 1. Study Population Characteristics and Main Study Variables

Characteristics	Group A (3 in 1 block)		Group B (Meperidine)		P values
Number of patients	21		21		
Gender (N)	Male	Female	Male	Female	0.747
	8	13	7	14	
Mean Age	67± 5 (median 65.8)		69 ± 4 (median 68.7)		0.510
Number of meperidine boluses demanded	0.25 ± 0.58		10.4 ± 1.1		0.001
Total dose of meperidine (mg)	12.5 ± 29		520 ± 55		0.001
Days to walk	1.3 ± 0.6		2.2 ± 0.7		0.001
Blood Loss (ml)	390 ± 120		480 ± 90		-
Hospital Stay (days)	7.4 ± 0.6		8.2 ± 0.8		0.002

The Chi-square test was used for sex comparison, the T-test for meperdine boluses and dose, while the Mann-Whittney U test was used for all other variables. No P value is provided for blood loss as there are values missing.

Table 2. Mean Values of VAS Scores Movement

Hours post OP (h)	Group A (3 in 1 block)	Group B (Meperidine)	P values
	VAS Score Movement		
1	0.625±0.25	17±0.9	0.001
6	0.0±0.0	32.5±0.44	0.001
9	1.25±0.50	21.25±0.34	0.001
24	28.12±0.98	32.5±0.44	0.012
48	38.75±4.31	30.62±0.25	0.275
72	25.62±0.51	30.62±0.57	0.003

The mean values of VAS scores during movement in both groups at different times, as shown on the vertical axis. Note that at 48 h the scores of the 3-in-1 group are a higher than the control. The Mann-Whitney U test was performed for data analysis.

Table 3. Mean Values of VAS Scores at Rest

Hours Post OP (h)	Group A (3 in 1 block)	Group B (Meperidine)	P values
	VAS Score at rest		
1	0.0 ± 0.0	12.50±0.44	0.001
6	0.0 ± 0.0	21.25±0.50	0.001
9	0.0 ± 0.0	10.0±0.63	0.001
24	13.12±0.79	21.25±0.34	0.001
48	13.75±0.80	19.37±0.57	0.015
72	11.25±0.88	21.87±0.75	0.001

The mean values of VAS scores at rest in both groups at different times, as shown on the vertical axis. The Mann-Whitney U test was performed for data analysis.

Discussion

In the present study, we compared the impact of two different guideline-recommended (7) methods of management of postoperative pain after Total Knee Replacement surgery. However, numerous other techniques are usually employed such as: i) demand-adapted intravenous analgesia (PCA), ii) epidural analgesia with opioids, local anesthetics or both, iii) lumbar nerve block, iv) standard analgesia per os or intramuscularly v) peripheral nerve blocks vi) local infiltration (8, 9). Of the most commonly used, both systemic opioids with conventional PCA and NSAIDs have several side effects and result in inadequate pain control, making the initiation of early intense physical therapy impossible. Respectively, epidural analgesia with continuous infusion of opioids and/or local anesthetics may result in bilateral motor blockade, and side effects such as nausea, urinary retention, pruritus and respiratory depression. This is the reason why the literature has mainly focused on peripheral nerve blockade. Working in this direction, we studied the efficacy of the 3-in-1 block, and we showed clearly that it provides superior analgesia compared to systemic opioid administration. The "3-in-1" nerve block has been proven to be an effective form of pain control after open knee surgery, with local anesthetics injected into the nerve sheath of the femoral, the femoral lateral cutaneous and the obturator nerve (4, 10-14). Consequently, the anatomical distribution of these nerves may explain our finding at 48h (the moment of the most intense mobilization) as patients mentioned pain in the posterior area of the knee, as the afferent fibers travel through the sciatic nerve branches.

Several variants of the 3-in-1 approach have been reported over the years in the literature, either using a single shot or continuous infusion. This technique, which was also adopted in our study, was first described by Winnie et al. (15) in 1973 as a superior alternative to femoral nerve block. The rationale behind this method was to substitute unilateral epidural analgesia. This is possible owing to the anatomical enclosure of the femoral, lateral cutaneous and obturator nerves in a common sheath, beginning almost right after the merger of the nerve root. In order to achieve this type of analgesia with a single shot technique, higher volumes of local anesthetics are used (approximately 40 ml compared to 15-20ml) with simultaneous distal pressure on the nerve sheath to achieve central dispersion of the anesthetic. On the other hand, when a catheter is introduced, it is directed cephalad and not distally as in continuous "femoral nerve block" (FNB).

The efficiency of the 3-in-1 femoral nerve block using different local anesthetics as well as different concentrations, for treating severe postoperative pain after TKR was tested by Ng et al. (11) The study showed no statistically significant difference between ropivacaine and bupivacaine groups in

terms of equianalgesic doses. Furthermore, no advantage was shown using a higher concentration of ropivacaine (0.25% vs 0.5%). The results of this study are in agreement with our results, confirming the effectiveness of the 3-in-1 nerve block in pain control after TKR.

To further evaluate the efficiency of this method, other researchers also compared it with intravenously injected opioids or regional techniques. Specifically, Ozen et al. (12) tested the use of a single-shot 3-in-1 femoral nerve block preoperatively in patients undergoing total knee replacement, and found a significant decrease in postoperative morphine consumption. The 3-in-1 nerve block group that received 40ml 0.375% ropivacaine, experienced no pain eight hours after surgery in the recovery room, and morphine requirements were significantly lower 12, 18, 24, 48 hr after TKR ($P<0.001$), which also decreased the occurrence of complications. The second group received only 2 mg of morphine as a loading dose 30 minutes before the end of surgery, and experienced pain of medium severity in the immediate postoperative period, which was sufficiently controlled (VAS score ≤ 30) with supplementary analgesia within the first hour in the post-anesthesia care unit (PACU).

In another fundamental study in the field, F J Singelyn et al. (10) compared a continuous 3-in-1 block with standard morphine PCA and epidural anesthesia. Their results also suggested that both epidural and nerve blocks provide superior analgesia after TKR, but the epidural was associated with four times more complications than continuous femoral nerve block. Complications such as urinary retention, arterial hypotension, and motor block are quite common. Problems related to epidural catheters must also be considered when choosing an analgesic regimen, for example, the challenging management of anticoagulants as prophylaxis for deep vein thrombosis, and the possibility of the failure of a central neuraxial block (16). The absence of such limitations with the 3-in-1 block highlights the importance of having this technique in our therapeutic armoire.

Similar results were also shown by Theodosiadis et al. (17) regarding anesthetic and analgesic effects, with ropivacaine having a significantly faster onset time. The researchers in this study suggest that not only the onset time but also the duration of the blockade, and the safety of the injected drug should be considered in order to select the optimal substance for the 3-in-1 block. They also mention that, despite the good safety profile of this method, complications may also exist, such as incomplete nerve blockade, direct nerve trauma, with potential quadricep wasting, local hematoma, ischemic injury, and infection, or even falls (18), suggesting the need for frequent reassessment of patients, especially of their motor function (17). On the other hand, adductor canal block permits early ambulation as it does not affect motor function. The continuous infusion variant in particular has a similar safety and efficacy profile to continuous femoral nerve block (19, 20). This explains why this approach is currently commonly used for TKA pain management and has become the subject of recent studies published in the literature (19, 20). However, we found no studies directly comparing continuous adductor canal block to the continuous 3-in-1 nerve block variant.

It is also important to mention that it is quite ambiguous whether the 3-in-1 block is actually a different modality (21) to the well-known femoral nerve block as far as the clinical effect is concerned. Despite the well-described steps of this variation and verification via magnetic resonance imaging, showing that there is a different dispersion of the local anesthetic centrally, in a limited number of patients this technique failed to achieve sufficient levels of analgesia, which was possibly attributed to anatomical (22) or technical factors. Capdevilla et al. (23) showed that only 40% of catheter tips were in the 'ideal' position, but with no correlation with the final analgesic effect. Due to these phenomena, in the literature 3-in-1 block is included within the wider term of FNB, and some researchers even suggest abandoning the term (24). This could be a limitation both to our study and others investigating the 3-in-1 variation of femoral nerve block as far as comparison and interpretation of results is concerned.

Finally, the recent systematic reviews and metanalyses by Karlsen et al. (13) and Chan EY et al. (14) document the efficacy and safety of analgesic interventions after total knee replacement, demonstrating that there is no optimal strategy to manage postoperative pain after TKR. The acceptable level of pain presented great variability in trials, something to be expected when taking the subjectivity of pain perception into account. In some of them, no basic analgesic substance was used and high pain scores were accepted, whereas in others several pain management interventions were tested, e.g. FNB etc. The differences led to considerable sensitivity variance between trials, which was probably caused by the several factors that differed between the study groups, making it almost impossible to interpret and compare results safely. Despite the mediocre level of bias between studies included in the metanalysis mentioned above, continuous femoral nerve block (3-in-1 included) achieved a mean opioid-sparing effect that was similar to the one-shot technique, and both were somewhat superior to placebo/standard opioid analgesia according to the results after the first 24 h. Furthermore, the continuous nerve block variant showed its benefit at 24h with lower VAS scores, especially during movement, compared to the one-shot. Such benefits would be even more prominent if the analysis also included the subsequent postoperative days, as suggested by our study.

Limitations of Study

Both the retrospective analysis method and the small number of patients included, are limitations of this study.

Conclusion

The efficiency of 3-in-1 nerve block as a postoperative pain managment intervention in patients after TKR and its superior analgesic effects are further verified in our study, justifying the inclusion of this peripheral nerve blockade approach, in current pain management guidelines. However, further double-blind, randomized, multi-centered studies are required to elucidate the labyrinthine pathway of pain management in such cases. Future studies should focus on showing the most effective femoral nerve block variation, but also evaluating the use of adjuvants in 3-in-1 block in order to optimize our practice.

What Is Already Known on This Topic:
Several systematic reviews and metanalyses show the superiority of regional techniques over opioids and IV analgesics in the management of postoperative pain after TKR, with most studies being in favor of neural blocks due to their safety profile. Simultaneously, several problems are mentioned in the same studies with failure of or insufficient analgesia when a single nerve is targeted, thus reintroducing the need for systematic analgesia as a rescue solution, or performing multiple blocks. The variability of study designs with several comparisons between different analgesic regimens in each study does not provide us high levels of evidence so the guidelines still suggest all approaches (IV analgesics, nerve blocks and neuraxial anesthesia) as preferable for pain management.

What This Study Adds:
This study further verifies the superiority of nerve blocks and especially of the 3-in-1 block variant which simultaneously targets more than one nerve, providing superior levels of analgesia, with mean VAS scores of less than 2 and 3 at rest and during movement, respectively. These findings suggest that the 3-in-1 block variant should not be abandoned. Furthermore, in the discussion part, we summarize several reasons that explain the variability of the success rates of this technique among patients, which may have led to misinterpretation of results in past studies and which possibly explain the inhomogeneity of pain management in everyday clinical practice.

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