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The effects of axillary block using the multiple injection method with ropivacaine in uremic and nonuremic patients*

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Aim: To compare the sensory and motor block quality in axillary brachial plexus block using the multiple injection method with ropivacaine in uremic and nonuremic patients.

Materials and methods: Examined were 60 patients scheduled for orthopedic surgery of the distal upper extremity (nonuremic group: group N, n = 30) or creation of an arteriovenous fistula (uremic group: group U, n = 30) with an axillary brachial plexus block. The median, radial, ulnar, and musculocutaneous nerves were selectively localized by nerve stimulation. After obtaining an appropriate peripheral motor response, predetermined volumes of ropivacaine (0.5%), in accordance with a formula, were selectively injected to the 4 nerves by multiple injections in both groups. Sensory and motor block were assessed.

Results: At 30 min, complete sensory and motor block was observed at a rate of 95% in the ulnar nerve innervation area and 100% in the other 3 nerves in group U, whereas these rates were 95% in the musculocutaneous nerve innervation area and 100% in the other 3 nerves in group N. There was no statistically significant difference between the groups.

Conclusion: Axillary brachial plexus block using the multiple injection method with ropivacaine in uremic and nonuremic patients provided a similarly good quality of the block and lack of systemic toxicity.

Key words: Axillary block, multiple injections, ropivacaine, uremic patient

Üremik olan ve olmayan hastalarda ropivakain ile çoklu enjeksiyon yöntemi kullanılarak yapılan aksiller bloğun yayılımı

Amaç: Çalışmamızda, üremik olan ve olmayan hastalarda, ropivakain ile çoklu enjeksiyon yöntemi kullanılarak yapılan aksiller blokta oluşan duyusal ve motor bloğun kalitesini karşılaştırdık.

Yöntem ve gereç: Ortopedik distal üst ekstremite cerrahisi (üremik olmayan grup; grup ÜO, n = 30) ya da arteriovenöz fistül açılması (üremik grup; grup Ü, n = 30) planlanmış 60 hastada aksiler brachial plexus bloğu uygulanarak çalışma yapıldı. Median, radial, ulnar, ve muskulokutanöz sinirler sinir stimülatörü ile selektif olarak stimüle edildi. Her iki grupta da benzer şekilde, uygun periferik motor yanıt alındıktan sonra çoklu enjeksiyon yöntemi ile dört sinire selektif olarak, formüle göre önceden belirlenmiş volümde ropivakain (% 0,5) enjeksiyonu yapıldı. Duyusal ve motor blok değerlendirildi.

Bulgular: Otuzuncu dakikadaki tam duyusal ve motor blok, grup Ü'de, ulnar sinir innervasyon alanında % 95, diğer üç sinirde % 100; grup ÜO'da ise muskulokutanöz sinir innervasyon alanında % 95, diğer üç sinirde % 100 oranlarında gözlenmiştir. Gruplar arasında istatistiksel olarak belirgin bir fark yoktur.

Sonuç: Ropivakain ile çoklu enjeksiyon yöntemi kullanılarak yapılan aksiller blokta, üremik olan ve olmayan hastalarda benzer şekilde iyi kalitede ve sistemik toksisite olmaksızın blok sağlanmaktadır.

Anahtar sözcükler: Aksiller blok, çoklu enjeksiyon, ropivakain, üremik hasta

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Introduction

A common regional anesthetic technique used for surgical anesthesia of the arm and hand is the axillary approach to neural block of the upper extremity. An axillary block is frequently used, not only in a variety of orthopedic and soft tissue surgical procedures of the upper extremity, but also in patients with end-stage renal disease who have to undergo arteriovenous fistula creation or revision for hemodialysis access (1). These patients are governed by the presence of risk factors such as hypertension, anemia, coagulopathy, metabolic acidosis, and/or hyperkalemia, which are directly associated with uremia, and many others such as ischaemic heart disease, diabetes, mellitus and chronic pulmonary disease (2). When a brachial plexus block is performed for procedures related to vascular access for hemodialysis, the resulting analgesia and sympathetic blockade provide optimal surgical conditions and, subsequently, adequate duration of the postoperative block prevents arterial spasm and graft thrombosis (3).

Since toxicity of local anesthetics with an axillary block is increased in uremic patients, selection of the local anesthetic and block procedure are important. The increased toxicity and shorter duration of axillary block in uremic patients is known (1,4-6), the lower toxicity of ropivacaine is known, and axillary block with ropivacaine in uremic patients has already been reported (7). In contrast to those reports, in order to identify the merit of the multiple injection method of axillary block, we compared the quality of sensory and motor block with ropivacaine between uremic patients and nonuremic patients.

Materials and methods

This study was approved by the local ethics committee, and informed consent was obtained from all of the patients. The patient population included patients of American Society of Anesthesiologists physical status I-III, aged 18-65 years, and scheduled for orthopedic surgery of the distal upper extremity (nonuremic group: group N, n = 30) or creation or revision of an arteriovenous fistula (uremic group: group U, n = 30) with an axillary brachial plexus block. Patients with a history of neurological, neuromuscular, or psychiatric disorders or hepatic, respiratory, or cardiac diseases were excluded. Patients with a history of drug or alcohol abuse, coagulation disorders, or uncontrolled seizures were also excluded, as were pregnant or lactating women.

No drugs as premedication were given to the patients, whose routine laboratory examinations were conducted preoperatively, prior to the surgery, since full cooperation during block assessment was required. All of the uremic patients included in the study were chronic hemodialysis patients and they had received hemodialysis treatment 1 day before the block performance. Prior to the procedure, all of the patients had a normal prothrombin time and partial thromboplastin time. After arrival in the anesthetic room, an 18- or 20-gauge intravenous catheter was placed in the upper limb, contralateral to the surgical site. A venous blood gas sample was taken in a 2-mL injector containing heparin and assessed in a blood gas device (Nova Biomedical, USA). From this vascular access, normal saline was given at an hourly rate of 2 mL/kg. Monitoring included electrocardiography (ECG), noninvasive blood pressure, and pulse oximetry. Supplemental oxygen (nasal cannula at 4 L/min) was applied throughout the procedure. A perivascular axillary brachial plexus block was performed. The plexus was identified with a short-beveled electric stimulation needle (Stimuplex, B. Braun Melsungen AG, Germany) connected to a nerve stimulator using a low current (<1.0 mA). The volume of local anesthetic for each patient was calculated according to a formula that takes height as a criterion [(volume (mL) = height (cm) / 5)] (8). The median, radial, ulnar, and musculocutaneous nerves were selectively localized by elicited characteristic muscle group movements, secondary to each nerve stimulation. After obtaining an appropriate peripheral motor response with a current near or below 0.5 mA with respect to the stimulation of each nerve, predetermined volumes (30-35 mL) of ropivacaine, in accordance with the formula at a concentration of 0.5% (Naropin, 5 mg/mL ampoule, Astra Zeneca, Sweden), were selectively injected into each nerve; that is, the predetermined volume was divided into equal amounts, through multiple injection in both groups, with intermittent aspiration. Verbal contact with the patients was maintained throughout the injection, and before the injections were made, the patients were informed about the

signs of local anesthetic toxicity, such as numbness of the lips and tongue and lightheadedness. Firm digital pressure was maintained during the injection and 3 min thereafter, immediately distal to the injection site, to prevent distal flow of the ropivacaine solution. The arm was then brought to rest at the patient's side. The hemodynamic parameters of heart rate, mean arterial pressure, and oxyhemoglobin saturation were monitored and recorded every 15 min during the procedure.

The time of injection was considered the beginning of all of the time intervals (time zero). Sensory and motor block were assessed in each of the 4 major peripheral nerve distributions at 3, 6, 9, 12, 15, 18, and 30 min and, thereafter, every 15 min during the procedure and until recovery. Sensory block was assessed by pinprick using the blunt end of a 27-gauge dental needle and was graded according to the following 3-point scale: 0 = no block (normal sensation), 1 = partial block (decreased sensation), and 2 = complete block (no sensation). Motor block was measured by assessing the following motor functions: flexion at the elbow (musculocutaneous nerve), extension of the elbow and the wrist (radial nerve), opposition of the thumb and index finger (median nerve), and opposition of the thumb and small finger (ulnar nerve). Motor block was graded according to the following scale: 0 = no block (full muscle activity), 1 = partial block (decreased muscle activity), and 2 = complete block (no muscle activity). The overall maximal composite score was 16 points. We considered the patient ready for surgery when a minimal composite score of 14 points was achieved, provided that the sensory block score was equal to or greater than 7 of 8 points (9). The onset time was defined as the amount of time required to obtain 14 points. After 30 min, the patient was transferred to the operating room for the start of the surgery. Independently of the composite score, we deemed a block successful if it provided surgical anesthesia. The occurrence of pain during surgery rendered the block a failure, and the patients were allowed local anesthetic infiltration by the surgeon. Requirements for additional local anesthetic infiltration and the incidence of complications were noted. Duration of sensory block (defined as a return of sensation to pinprick in all of the nerve distributions) and duration of motor block (time from onset to a motor block score of 0 for all of the activities) were also measured. After the operation, patients were monitored in the postanesthesia care unit and were discharged from the hospital after recovery from sensory and motor blockade.

The results are expressed as mean values with standard deviations. An unpaired Student's t-test or a Mann-Whitney U was used to compare the demographic variables and operative data. For the analysis of the quality of the block, a chi-square or Fisher's exact test was used. Differences were regarded as statistically significant if $P < 0.05$.

Results

Demographic data were not significantly different between the 2 groups, except for sex ($P < 0.01$). No differences were observed in terms of the durations of operation (Table 1).

The preoperative venous blood gas and electrolyte values of the patients are presented in Table 2; it was observed that the hemoglobin and Ca values of the uremic group were significantly ($P < 0.01$) lower than the values of the nonuremic group, whereas the blood urea nitrogen (BUN) and creatinine values of the same group were significantly higher ($P < 0.01$). Again in the uremic group, the pH and HCO_3^- values were significantly lower ($P < 0.01$), whereas the base excess values were significantly higher ($P < 0.01$). No statistically significant differences were found between the 2 groups in terms of the other laboratory values.

At 30 min following the block (Figures 1 and 2), the score of 14 points required to start the operation in the musculocutaneous, radial, median, and ulnar nerves was reached in 100% of the patients in both the nonuremic and uremic groups. There were no differences in surgical anesthesia and in the proportion of the blocks achieving a minimal composite score of 14 points at 30 min. Motor and sensorial block developed in the radial and median nerves in 100% of the patients in both groups. Complete sensory and motor block developed in the musculocutaneous nerve in 95% of the patients in group N and in 100% of the patients in group U, and in the ulnar nerve in 100% of the patients in group N and in 95% of the patients in group U.

Table 1. Patient characteristics and duration of operation and sensory and motor block (mean ± SD).

Groups	Nonuremic (n = 30)	Uremic (n = 30)	P-value
Sex (M/F)	8/22	18/12	<0.01
Age (years)	45 ± 10	49 ± 16	NS
Weight (kg)	73 ± 8	66 ± 12	NS
Height (cm)	166 ± 8	165 ± 12	NS
Duration of operation (min)	59 ± 21	61 ± 24	NS
Duration of sensory block (min)	571 ± 57	561 ± 51	NS
Duration of motor block (min)	704 ± 45	682 ± 53	NS

Table 2. Preoperative venous blood gas and electrolyte values (mean ± SD).

Venous blood gas and electrolytes	Nonuremic (n = 30)	Uremic (n = 30)	P-value
BUN (mg/dL)	18.9 ± 9.0	63.1 ± 18.1	<0.001
Creatinine (mg/dL)	0.82 ± 0.2	5.05 ± 1.9	<0.001
Hemoglobin (g/dL)	13.32 ± 2.0	11.21 ± 1.5	<0.001
K^+ (mEq/L)	4.21 ± 0.4	4.40 ± 0.6	NS
Albumin (g/dL)	4.09 ± 0.5	3.62 ± 0.6	NS
Ca (mg/dL)	9.2 ± 0.5	8.2 ± 0.7	<0.001
pH	7.42 ± 0.13	7.36 ± 0.05	<0.001
pCO_2 (mmHg)	40.1 ± 4.4	37.2 ± 5.8	NS
pO_2 (mmHg)	46.0 ± 13.1	47.0 ± 9.9	NS
Base excess	–1.8 ± 2.3	–4.1 ± 4.6	<0.001
HCO_3^- (mEq/L)	26.2 ± 1.6	21.6 ± 3.3	<0.001

Partial motor and sensory block was observed in the musculocutaneous nerve in 1 patient (5%) in group N, and in the ulnar nerve in again 1 patient (5%) in group U. When the sensory and motor development speed was considered following the axillary block, no statistically significant differences were observed between the 2 groups. However, the sensory block speed in the radial nerve at 9 min in group N was significantly higher ($P < 0.05$) than in group U.

Durations of the sensory as well as the motor block (Table 1) were not significantly different between the groups. No additional local anesthetic infiltration was administered to any of the patients prior to or during the operation.

No statistically significant differences were found between the 2 groups in terms of the mean arterial pressure values at all of the measurement times, and they were within the normal limits. Additionally,

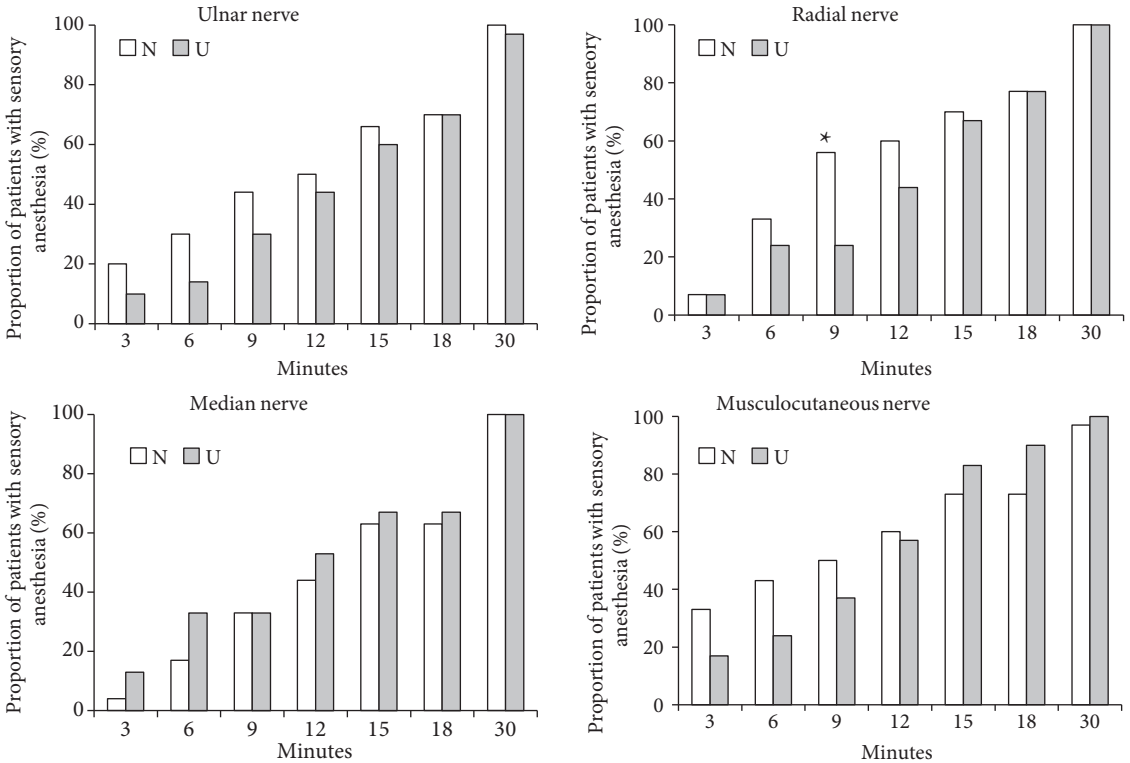

Figure 1. Percentage of patients with sensory anesthesia (score of 2) according to time in the cutaneous distributions of the radial, median, ulnar, and musculocutaneous nerves. *P < 0.05

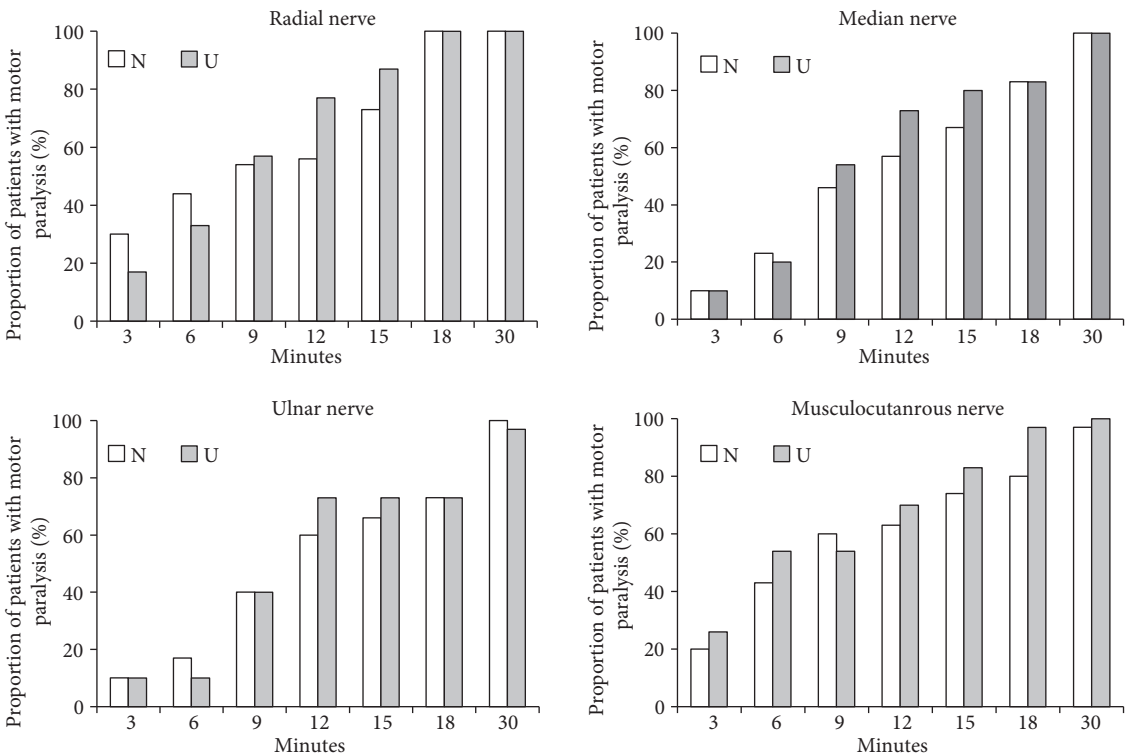

Figure 2. Percentage of patients with motor paralysis (score of 2) according to time in the cutaneous distributions of the radial, median, ulnar, and musculocutaneous nerves.

vascular puncture occurred in a total of 5 cases, 1 in group N and 4 in group U. Signs of toxicity related to local anesthetics were not noted in any of the patients in either group.

Discussion

In the present study, brachial plexus block was performed on uremic and nonuremic patients at a volume that was calculated according to a formula that takes height as a criterion (8), using ropivacaine at a concentration of 0.5% with an axillary approach through the multiple injection method. At the end of the study, in the nerves examined in both groups, no statistically significant difference between the groups was found in terms of sensory and motor block quality in all of the periods of time. The duration of sensory and motor block in the uremic patients was not significantly different from that of the nonuremic patients. Signs of toxicity related to local anesthetics were not noted in any of the patients in either group. No significant differences were found between the 2 groups hemodynamically.

It is reported that acidosis and hyperkalemia present in chronic renal failure increases the local anesthetic-related cardiotoxicity in the case of a possible intravascular injection (4). The use of long-acting local anesthetics is recommended for uremic patients (10). In studies that compare the acute toxicity of ropivacaine to bupivacaine, it is reported that ropivacaine is at least 25% less toxic than bupivacaine and that the threshold value of central nervous system toxicity for ropivacaine is twice that of bupivacaine (11,12). In this study, we preferred to use ropivacaine for high-risk uremic patients, as the cardiotoxicity risk is lower in the case of a possible intravascular injection.

Patients with end-stage renal disease may present several clinical characteristics that may predict differences in the systemic uptake and distribution of local anesthetics when compared with patients with normal renal function. Such characteristics include a hyperdynamic circulatory status, alterations in plasma protein concentrations, and acidemia (5,6,13-15). The duration of brachial plexus block with lidocaine, mepivacaine, and bupivacaine has been reported to be shorter in uremic patients than in nonuremic patients (10,16). This is possibly because of the fast absorption of the local anesthetic from the region of the brachial plexus into the circulation. However, no differences were reported in some other studies with respect to patient-reported duration of the brachial plexus block with lidocaine or bupivacaine (17). The plasma concentrations of bupivacaine after brachial plexus block were larger (16) than, or similar (17) to, those in nonuremic patients.

Ropivacaine, used as the local anesthetic in this study, was previously used by Pere et al. (7) for brachial plexus block with an axillary approach in uremic and nonuremic patient groups. However, different from the current study, they administered 50 mL of 0.5% ropivacaine using the single injection method for each patient. They concluded that uremic and nonuremic patients exhibited a similar quality of axillary brachial plexus block with ropivacaine. However, the pharmacokinetic data of their study showed that in uremic patients, faster absorption into the circulation and increased binding to α_1-acid glycoprotein, reducing liver extraction, led to significantly larger plasma concentrations of ropivacaine. Again in the same study, a successful sensory block was obtained in the uremic patients in the innervation areas of the musculocutaneous, radial, median, and ulnar nerves at rates of 90%, 83%, 93%, and 100%, respectively, and in the nonuremic patients in the innervation areas of the musculocutaneous, radial, median, and ulnar nerves at rates of 89%, 96%, 100%, and 100%, respectively. When considered in terms of motor block, excluding forearm flexion, no significant differences were observed between the 2 groups. It was observed that forearm flexion fully disappeared at a rate of 72% in the uremic patients and 82% in the nonuremic patients.

Additionally, when the qualities of sensory and motor block in the uremic and nonuremic patients in the present study on whom axillary block was performed were compared, no significant differences were found between the 2 groups. In the uremic group, complete sensory and motor block was observed at a rate of 95% in the ulnar nerve innervation area and 100% in the other 3 nerves; in the nonuremic group, complete sensory and motor block was observed at a rate of 95% in the musculocutaneous nerve innervation area and 100% in the other 3 nerves. Even

though a higher volume of ropivacaine (50 mL) was used in the study mentioned above (7) than in this study (30-35 mL), the block success rates obtained in this study were higher.

As reported in the literature, the type of surgery was different in the uremic patients (arteriovenous fistula on the forearm) and the nonuremic patients (various operations of the forearm, wrist, and hand); therefore, the onset of pain cannot be considered a reliable measure of the duration of the block (7). Moreover, when the block durations in the uremic and nonuremic groups were examined, it was found that the duration of sensory and motor block in the uremic group was not significantly different from that in the nonuremic group.

In brachial plexus block performed with an axillary approach where paresthesia-seeking, nerve-stimulating, perivascular, transarterial, or ultrasound-guided techniques are used, successful blockade of individual nerves varies from 60% to nearly 100%, depending on the technique (18). Though expensive, use of ultrasound to guide injections is growing (19). In the studies performed, it has been concluded that ultrasound guidance has resulted in either similar (20) or marginally higher success rates when compared with nerve-stimulating (21) or perivascular techniques (22). In a study conducted by Koscielniak-Nielsen (23), it is stated that ultrasound guidance shortens the block performance time, reduces the number of needle insertions, and shortens the block onset time, and, furthermore, that blocks may be performed using lower local anesthetic doses. Additionally, in the same study, it was pointed out that block effectiveness is not significantly better than using a nerve stimulator, but ultrasound is probably more effective than other methods on nerve localization.

According to the research reported in the literature, blocks performed using 2-, 3-, or 4-injection methods result in higher success rates, shorter latency, and higher complete block rates when compared to the single injection method (24-28). Fanelli et al. (29) reported a success rate of 94% using local anesthetics (less than 30 mL) and the multiple injection method in their retrospective study. The effects of the multiple injection method on uremic patients are not stated in the above studies. However, based on the findings of the present study, it is thought that even though a lower volume was administered, the block success rate increased as a result of the multiple injection method used.

Axillary brachial plexus block using the multiple injection method with ropivacaine in uremic and nonuremic patients provided a similarly good quality of block and lack of systemic toxicity. For this reason, we suggest that, in uremic patients, the performance of an axillary block through multiple injections for fistula operations may increase the block success rate when compared to the single injection method.

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