



SCIENTIFIC ARTICLE

Faster onset time of supraclavicular brachial plexus block using local anesthetic diluted with dextrose[☆]



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KEYWORDS

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Abstract

Background and objectives: A high sodium concentration is known to antagonize local anesthetics when infiltrated around neural tissue. Thus, we hypothesized that the onset time for sensory and motor blockade, in supraclavicular brachial plexus block using ropivacaine diluted with dextrose would be shorter than with saline.

Methods: Patients scheduled for upper limb surgery were randomized to receive ultrasound guided supraclavicular brachial plexus block with 0.5% ropivacaine. Evaluation of sensory and motor blockade was performed every 5 min for 60 min. Patients were followed-up on postoperative day 1, and between days 7 and 10 for the presence of any complications. Twenty-five patients in each group were analyzed.

Results: Mean time for onset of analgesia for the dextrose group was 37.6 ± 12.9 min while the mean time for the saline group was 45.2 ± 13.9 min with a *p*-value of 0.05. The effect size was 0.567, which was moderate to large. No major complications were observed.

Conclusion: We conclude that there was a decrease in onset time of analgesia when dextrose was used as a diluent instead of saline for ultrasound guided supraclavicular block.

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PALAVRAS-CHAVE

Ultrassom;
Supraclavicular;
Plexo braquial;
Bloqueio;
Solução salina;
Dextrose

Tempo mais rápido de início do bloqueio do plexo braquial supraclavicular usando anestésico local diluído com dextrose

Resumo

Justificativa e objetivos: A alta concentração de sódio é conhecida por antagonizar anestésicos locais quando infiltrado em torno de tecido neural. Portanto, a nossa hipótese foi a de que o tempo de início para os bloqueios sensorial e motor, em bloqueio do plexo braquial supraclavicular usando ropivacaína diluída com dextrose, seria menor do que com solução salina.

Métodos: Os pacientes agendados para cirurgia em membro superior foram randomizados para receber bloqueio do plexo braquial supraclavicular com ropivacaína a 0,5% guiado por ultrassom. A avaliação dos bloqueios sensorial e motor foi realizada a cada 5 minutos durante 60 minutos. Os pacientes foram acompanhados no pós-operatório no primeiro dia e, entre os dias 7-10 para presença de qualquer complicação. Foram analisados 25 pacientes em cada grupo.

Resultados: A média do tempo para o início da analgesia no grupo dextrose foi de $37,6 \pm 12,9$ minutos, enquanto que no grupo solução salina a média foi de $45,2 \pm 13,9$ minutos, com um valor-*p* de 0,05. O tamanho do efeito foi 0,567, o que foi de moderado a grande. Complicações maiores não foram observadas.

Conclusão: Concluímos que houve uma redução do tempo de início da analgesia quando dextrose em vez de solução salina foi usada como diluente para bloqueio supraclavicular guiado por ultrassom.

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Introduction

Regional anesthesia with local anesthetics blocks specific nerves to enable pain free surgery, or for intra- and postoperative pain relief. Dilution of local anesthetics with normal saline is a common practice to enable administration of larger volumes of local anesthetics particularly in cases whereby multiple nerve blocks are needed. This will also minimize the risk of systemic toxicity.

Local anesthetics block the function of sodium channels located in neural tissue, inhibiting depolarization and thus the transmission of nerve impulses.¹ A high sodium concentration is known to antagonize the analgesic effect of local anesthetics.² On the other hand, dextrose when injected around nervous tissue does not cause any pain on injection and does not cause any long term neurological deficit in animals or humans.³⁻⁵ Dilution with dextrose would reduce the concentration of sodium ions and hence reduce its antagonistic effect. In the literature, only one study using dextrose as diluent to produce 0.5% ropivacaine for axillary brachial plexus block showed a reduction in the onset time for sensory blockade when compared with dilution with saline.⁶ Our hypothesis was that dilution of the local anesthetics with dextrose would shorten the onset time compared to saline for a supraclavicular brachial plexus block.

In the present randomized and blinded clinical study, 0.75% ropivacaine was diluted with dextrose or saline to produce 0.5% ropivacaine, for ultrasound guided supraclavicular brachial plexus block. The primary aim was to compare the onset time for complete analgesia and motor blockade in both groups. Analysis with regards to the duration of the neural blockade was also carried out.

Methods

This clinical study was registered at clinicaltrials.gov (ID no. NCT01815944). After obtaining approval from the Medical Ethics Committee, University Malaya Medical Centre (Ethics committee/IRB reference no. 883.11 dated 19 October 2011), patients aged between 18 and 85 years who were ASA I to III, scheduled for elective or emergency surgery of the hand, forearm and elbow were evaluated for eligibility to be enrolled in the study. Patients were excluded if they had a history of diabetes mellitus, any neurological deficit, contraindications to supraclavicular brachial plexus blockade, were unable to give consent, or refused to participate.

Upon obtaining written informed consent, patients were randomly assigned to either the dextrose (D5%) or normal saline (NS) group. Randomization was performed using a computer-generated random table and patients were blinded as to their group allocation. Group allocations were concealed in a sealed opaque envelope and were opened by an independent anesthesiologist just before the performance of the block. The same anesthesiologist prepared 20 mL 0.5% ropivacaine by diluting 13.3 mL of 0.75% ropivacaine with 6.7 mL of either dextrose or normal saline, depending on the patient's group allocation.

An anesthesiologist familiar with the technique, who was blinded to group allocation, performed all ultrasound-guided supraclavicular blocks. Prior to the block, all patients were placed supine on a trolley and were equipped with routine monitoring, i.e. ECG, SpO₂, NIBP, and a patent intravenous line. Patients were given IV midazolam 0.03–0.04 mg/kg before the brachial plexus blockade

to relieve anxiety but not to the point of being unable to respond clearly.

After the brachial plexus was identified using a Sonosite M-Turbo ultrasound machine and a 13–6 MHz linear probe (Sonosite®, Bothell, WA, USA), the adjacent skin area was cleaned with povidone iodine and draped. Under aseptic technique, a sterile 22G, 50 mm short bevel needle (Stimuplex®, B Braun, Melsungen, Germany) was guided in-plane with the ultrasound beam toward the plexus. Once at the appropriate location, local anesthetic was administered incrementally, each time after a negative aspiration, ensuring expansion and adequate spread around the brachial plexus. A total of 19 mL of local anesthetic was given each time; 1 mL from the initial 20 mL prepared being used to prime the catheter for the needle.

Evaluation of sensory and motor blockade was then carried out. The same anesthesiologist who performed the blocks and was blinded to group allocation did every evaluation. Sensory and motor blockade were tested, after injection of the local anesthetic, every 5 min until total analgesia was obtained in all four nerve distributions, or up till 60 min, whichever was earlier. Sensory loss was tested in the median, radial, ulnar, and musculocutaneous nerve distributions and evaluated using a three point score: two = normal, one = analgesia, i.e. loss of pinprick sensation, or zero = anesthesia, i.e. total sensory loss. The extent of motor blockade was tested in the distribution of the radial (thumb abduction, finger and wrist extension), ulnar (thumb adduction), musculocutaneous (flexion of the elbow in supination and pronation), and median nerves (thumb opposition) and evaluated using a three-point scale where two = normal movement, one = paresis with some movement possible, and zero = total paralysis.

Block success was defined as loss of sensation to pinprick (sensory score one) in each of the radial, ulnar, median, and musculocutaneous nerve distributions, measured up till 60 min after the end of local anesthetic injection. Patients in whom block success was not achieved after 60 min were excluded from data analysis. They were subsequently given appropriate individual nerve blocks at the axilla or elbow, or were given general anesthesia prior to proceeding with surgery.

Low-dose midazolam (1–3 mg) and/or propofol at conscious sedation doses (25–75 µg/kg/min) were given during surgery according to the usual standard of care at our center. In the event of inadequate analgesia intraoperatively, boluses of fentanyl (1–2 µg/kg) were given, followed by conversion to general anesthesia if necessary. Any adverse events were noted during and after the block performance.

The onset time for sensory blockade was taken as time from completion of injection of local anesthetic to time of complete analgesia in all four nerves. Time for motor blockade was taken as time from complete injection of local anesthetic to time of total motor block of the nerves assessed.

During the postoperative recovery period before being discharged to the ward, pain (verbal response score four or patient request for analgesic) was treated with IV tramadol 25–50 mg slow bolus with or without fentanyl 25 µg boluses every 5 min as needed. Once in the ward and when oral intake was allowed, patients received oral paracetamol 1 g with oral diclofenac 50 mg or celecoxib 200 mg, if

not contraindicated, when they felt the slightest pain from the operative site and requested oral analgesics. Patients were told to note the time to first request for analgesics. The block duration was subsequently taken as time from complete analgesia to the time when the patient first feels the slightest pain from the operative site and requests oral analgesics.

Patients were followed up twice; on postoperative day (POD) 1 and once between POD 7–10. They were seen in the ward or were contacted via telephone and asked for the presence of any pain, weakness, numbness, tingling, or any abnormal sensation in the operative extremity. If indicated, they were then told to return to the hospital for further evaluation and management as necessary.

The primary outcome measure for this study was the onset time of sensory blockade defined as the time interval between the end of local anesthetic infiltration and loss of sensation to pinprick. Dhir et al. reported a mean difference of 4.2 min in the onset time between the two compared groups. The pooled standard deviation was 6.25. Calculations based on this study showed that 25 patients per group were needed to detect a statistically significant difference between the groups with $\alpha = 0.05$ and a power of 80%.

For patient demographics, descriptive statistics were used. For the onset time of sensory blockade, the independent-t test was used. Individual nerve block times, total duration of block, total procedure time, and onset time for total paresis were also analyzed using the independent t-test. Data analysis was done using SPSS version 16 (SPSS Inc., Chicago, Illinois, USA).

We also calculated the effect size values in this study. Effect size values are typically computed to compare the effects of different treatments.⁷ It provides a measure to assess the magnitude of difference between groups that cannot be obtained solely by focusing on *p*-values. *p*-Values are dependent on both the magnitude of difference between groups and the sample size. Therefore with other factors held constant, increasing the sample size increases the probability of finding a statistically significant difference.⁸ In this study, effect size values were calculated in addition to *p*-values, to assess the magnitude and to strengthen the validity of our results. The effect size reported in this study was calculated as the 'standardized' mean difference, i.e. as the ratio of mean change to the standard deviation of the change.⁸ Effect size values between 0.2–0.5, 0.5–0.8 and >0.8 were taken to denote 'small', 'moderate' and 'large' changes in outcomes respectively.⁸

An independent medical statistician carried out all statistical analyses.

Results

The study was carried out between December 2011 and October 2012. A total of 104 patients were evaluated for eligibility, from which 55 were recruited and randomized. Successful blocks were subsequently obtained in 25 patients, in each arm (Fig. 1). For demographic data see Table 1. There was no difference between the NS and D5% groups with respect to duration of surgery. Halfway through the study after 23 patients the anesthesiologist evaluating

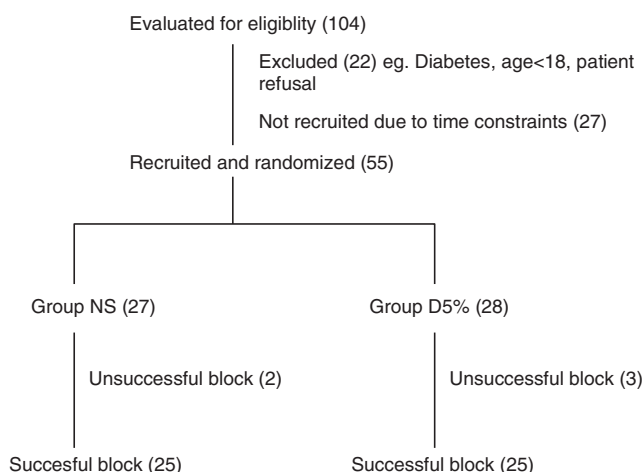


Figure 1 Consort diagram. NS-normal saline, D5%–dextrose 5%.

Table 1 Patient demographics. Values for age, sex, weight, height and ASA class.

	Group NS (n = 25)	Group D5% (n = 25)
Age, years	32 (16)	34 (13)
Sex, M:F	19:6	22:3
Weight, kg	65 (14)	68 (15)
Height, cm	159 (30)	167 (6)
ASA class, I/II/III	23/2/0	22/3/0

Continuous data are presented as mean (SD).

the block, also had to prepare the local anesthetic solution. There was however a larger number of males in each group.

Mean time for onset of analgesia for the NS group was 45.2 ± 13.9 min while mean time for the D5% group was 37.6 ± 12.9 min. The *p*-value of the test was 0.05, which is significant at the 5% level. The effect size was 0.567, which depicts a moderate change in outcome. Mean time for onset of analgesia for individual nerves showed no difference between the NS and D5% groups (Table 2).

The mean time for onset of motor block (total paralysis) could not be analyzed, as 90% of patients did not have complete paralysis at the endpoint of total loss of sensation to pinprick. The mean time for onset of total paresis was not statistically significant between the NS and D5% groups.

Block procedure time and sensory block duration were also not different between the two groups (Table 3).

Overall block success was 89% for the D5% group and 92% for the NS group, which were not different.

No patient needed rescue analgesia intra-operatively.

Post injection of local anesthetics, 2 patients, one from each group, developed Horner's syndrome, which they were unaware of, and this resolved spontaneously after 24 h observation.

One patient from the D5% group complained of weakness and shooting pains in the operative arm on POD 7. However upon further questioning and examination, it was discovered that the patient already had those symptoms bilaterally, prior to the operation and that those symptoms were actually worse on the contralateral arm. However as the symptoms had marginally worsened, the patient was referred for an MRI of the cervical spine. The patient was then referred for a nerve conduction study of the operative arm, which confirmed pathology at the level of the spinal cord.

Discussion

In this study, the mean time for onset of analgesia was 45.2 min and 37.6 min for the normal saline and dextrose groups, respectively. The *p*-value of 0.05, together with a moderate effect size of 0.567,⁸ makes us conclude that there is clinical evidence that dilution with dextrose results in a faster onset time of analgesia compared to dilution with normal saline. In this study, effect size values were calculated in addition to *p*-values, to assess the magnitude and to strengthen the validity of our results.⁸ Thus, we could also reasonably infer that this translates to a faster onset time for anesthesia. This finding is similar to another study by Dhir et al.⁶ Our slightly longer mean time for onset of analgesia as compared to some studies could be attributed to the consistent deposition of local anesthetic around the brachial plexus sheath (periplexus).^{6,9–11} This approach may avoid needle-to-nerve contact and thus reduce the possibility of nerve injury. However, one study found that up to 40 min was needed for complete analgesia and up to 50 min for total loss of sensation.¹¹

Mean time for onset of motor block could not be calculated, as a large number of patients did not have complete motor paralysis at the point of total loss of sensation to pinprick. This was unusual, as the concentration of 0.5% ropivacaine used should have produced total motor blockade as well as anesthesia. However, ropivacaine is also known to have less motor blockade than sensory blockade.¹² This might have accounted for this unusual finding. It could also

Table 2 Onset times for analgesia and individual nerves.

	Group NS (n = 25)	Group D5% (n = 25)	<i>p</i> -Value
Onset of analgesia, min	45.2 (13.9)	37.6 (12.9)	0.05
<i>Individual nerves</i>			
Radial, min	17.7 (8.9)	17.0 (10.0)	0.82
Median, min	37.4 (16.6)	31.0 (14.6)	0.15
Ulnar, min	40.8 (17.9)	33.9 (15.9)	0.16
Musculocutaneous, min	13.2 (7.7)	16.2 (8.6)	0.20

Values are mean (SD).

Table 3 Onset times for other end points.

	Group NS (n = 25)	Group D5% (n = 25)	p-Value
Block procedure time, min	7.5 (2.0)	7.4 (2.1)	0.89
Sensory block duration, min	527.6 (168.4)	583.0 (190.6)	0.30
Onset time for total paresis, min	14.2 (9.6)	10.8 (4.2)	0.13
Duration of surgery, min	109 (79)	89 (44)	0.32

Values are mean (SD).

be due to deposition of local anesthetic outside the brachial plexus sheath (periplexus).

Mean block procedure time of about 7.5 min for each group was not expected to be different as a single operator performed all blocks. This time was also comparable to a recent study that reported times of 7.3–7.6 min.⁶

Sensory block duration averaged more than 520 min or 8.5 h for both groups. However, the method of evaluating this duration of effect was by subjective patient feedback of the time they first felt pain. Offset of sensory and motor blockade was not assessed individually until full recovery when the patient had returned to the ward. Patients also received oral analgesia prior to block resolution to avoid rebound pain after return of sensation.

Despite the slightly longer mean time for onset of analgesia in this study, block success of 89% and 92% for the two groups were similar to the success rates for ultrasound guided supraclavicular brachial plexus blocks quoted in other studies, which ranged from 85 to 95%.^{9–11}

Horner's syndrome occurred in 2 (3.6%) of the patients in this study. This is slightly higher than 1% cited in one study, but was much lower than 37.5% cited in another.¹³ Hence, there is evidence of wide variations in incidence and some studies do not actually report the incidence of Horner's syndrome. Rather than a complication per se, it has been described as an unpleasant side effect with no clinical sequelae. Indeed, the two patients with Horner's syndrome in our study did not know they developed it until told.

The dominance of males in each group can be attributed to the fact that many of these patients were coming for plating of the radius or ulnar due to motor vehicle accidents, which have been shown to have a higher incidence in males.¹⁴ There are notable limitations in this study. The anesthesiologist evaluating the block was blinded till halfway through the study. Due to unforeseen circumstances, the preparation of the local anesthetic had to be carried out by him in the latter half. This inherently introduces operator bias to the study. However, block evaluation used a very clear and objective end point of loss of sensation to pinprick, which would have decreased the subjectivity of the evaluation by the assessor.

Summary

A faster onset time of analgesia to provide conditions suitable for surgery is what is desired in the daily running of the operating theater list and in optimizing efficient usage of theater time. Our study suggests a decrease in onset time of analgesia when dextrose was used as a diluent instead of normal saline for ultrasound guided supraclavicular brachial

plexus block. Further studies are required to ascertain if the results are similar for different concentrations of other local anesthetics, and for other ultrasound guided nerve blocks.

Conflicts of interest

The authors declare no conflicts of interest.

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