Original article

The effect of rocuronium added to lidocaine for upper limb intravenous regional anesthesia

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Objective This study aimed to determine the effect of rocuronium added to lidocaine on the onset and regression time of sensory and motor block, quality of anesthesia and postoperative analgesia in upper limb IVRA.

Methods Forty adult patients undergoing elective hand/forearm surgery under IVRA, according to American Society of Anesthesiologists physical status I and II, were allocated randomly into 2 groups: group I (control) received 3 mg/kg of lidocaine diluted with saline to a total volume of 40 mL and group II (rocuronium), 3 mg/kg of lidocaine plus 0.06 mg/kg of rocuronium diluted with saline to a total volume of 40 mL. The onset and regression time of sensory and motor block were recorded as well as perioperative pain scores and fentanyl requirement. Clinical side effects after tourniquet release were also noted.

Results The onset time of motor block in the rocurnium group was shorter than that in the control group (2.10±1.09 vs 26.00±8.20 min, $p<0.001$), while the regression time was longer in the former (25.50±10.37 vs 2.20±1.19 min, $p<0.001$). The quality of all anesthesia was excellent in the rocuronium group with no fentanyl requirement. However, postoperative fentanyl requirements were comparable between the two groups.

Conclusion The addition of rocuronium to lidocaine in upper limb IVRA shortened the onset time of motor block and improved overall quality of anesthesia without significant side effects.
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Keywords: intravenous regional anesthesia, muscle relaxant, rocuronium, local anesthetics, lidocaine

Introduction

Karl Gustav Bier first described the technique of intravenous regional anesthesia (IVRA) in 1908. However, it did not become popular until 1963, when Holmes reintroduced it as an anesthetic practice. IVRA is a cost-effective, simple and safe method of providing anesthesia for surgical procedures on the hand, forearm, foot, ankle or lower leg. The successful anesthesia rate falls between 96-100% of patients with minimal clinical side effects [1]. However, there are

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still some limitations to IVRA including local anesthetic toxicity, inadequate anesthesia, poor muscle relaxation and rapid onset of pain after tourniquet release [2]. Many drugs that include muscle relaxants have been added to local anesthetics during IVRA in order to improve the quality of anesthesia, decrease tourniquet pain and increase the length of postoperative analgesia. From published articles, pancuronium, atracurium, mivacurium and cisatracurium were among the muscle relaxants added to local anesthetics during IVRA, which resulted in better anesthesia outcome, but with some clinical side effects [3-8]. Rocuronium. has faster onset when compared with other available non-depolarizing muscle relaxants. This study aimed to determine the effect of 0.06 mg/kg of rocuronium added to lidocaine on the onset and regression time of sensory and motor block, quality of anesthesia and postoperative analgesia in upper limb IVRA.

Methods

This prospective, randomized, double-blind, controlled-trial study was approved by the Ethic Committee, Faculty of Medicine, Chiang Mai University, Thailand, Eligible subjects were in the American Society of Anesthesiologists physical status I or II, aged 18-60 years, and undergoing elective hand or forearm surgery. Patients who were known to be allergic to lidocaine or any muscle relaxant were not included in the study. Patients also faced exclusion if they were contraindicated to tourniquet use with sickle cell disease, Raynaud's disease or scleroderma, and those with severe hypertension (blood pressure > 160/110 mmHg) or peripheral vascular disease, local infection, and skeletal muscle disorders or Paget's desease were excluded as well [1].

After informed consent was obtained, 40 unpremedicated patients were enrolled in the study. Routine monitors were applied, and the patients were then randomly allocated into 2 groups, group 1and group 2, using a computer-generated number in a sealed envelope. The IVRA solution was either 3 mg/kg of lidocaine diluted with saline to a total volume of 40 mL (group 1) or 0.06 mg/kg of rocuronium plus 3 mg/kg of lidocaine diluted with saline to a total volume of 40 mL (group 2). Here, the IVRA technique applied a standard method with double cuffs to reduce tourniquet pain [9]. A double-cuff tourniquet was fitted securely to the operative arm and exsanguination was performed using a 10-cm Esmarch bandage. The proximal tourniquet was then inflated to 100 mmHg over the systolic blood pressure to a minimum of 250 mmHg, and the Esmarch bandage was removed. Intravenous access on the operative arm was done as distal as possible, and IVRA solution, being blind to the anesthesiologist, was injected slowly for 3 minutes. After the onset of sensory block, the distal tourniquet was inflated to the same pressure, and afterwards, the proximal tourniquet was deflated, and the surgical procedure started. An intermittent intravenous bolus of 25 µg of fentanyl was given intraoperatively to supplement analgesia if required (when the visual analogue scale reached > 3). At the end of surgery, tourniquet deflation was performed using the cyclic deflation technique, i.e. the cuff was deflated for 10 seconds and then reinflated for 1 minute. Two of these cycles were performed before the cuff was deflated permanently

Sensory block and sensory block regression, as well as motor block and motor block regression, were assessed in sequence by the same anesthesiologist at intervals of 30 seconds. Pinprick testing with a 25-gauge short bevel needle was used to assess sensory block at 3 sites; the thenar eminence (median nerve), hypothenar eminence (ulnar nerve) and first web space (radial nerve). The time from completing injection of IVRA solution to loss of pinprick sensation was recorded as the sensory block onset time. Motor block onset time also was noted when the patient could not move any fingers. At the end of surgery, after the tourniquet was deflated permanently, sensory and motor block regression were assessed as in the above-mentioned fashion. The time from tourniquet deflation to recovery of pinprick sensation was recorded as the sensory block regression time. Motor block regression time was noted when the patient could move all fingers.

Immediately on arrival at the recovery unit, the quality of anesthesia was assessed according to the following numeric scales: 4=excellent (no complaint from the patient); 3=good (minor complaint without a need for supplemental analgesics); 2=moderate (complaint requiring supplemental analgesics); 1=failed block (requiring general anesthesia) [7]. Postoperative pain was assessed using the 10-cm visual analogue scale (0=no pain to 10= worst pain) at 0 minute (just after tourniquet deflation), 15 minutes, 30 minutes, 1 and 2 hours after tourniquet deflation. An intermittent intravenous bolus of 25 µg of fentanyl was given to supplement analgesia when the visual analogue scale reached > 3. Intraoperative and postoperative fentanyl requirements were recorded.

Statistical analysis

Demographic data, duration of surgery, tourniquet time, sensory and motor block onset time, sensory and motor block regression time, and fentanyl requirement were analyzed using the Student's t test. Sex distribution and quality of anesthesia were analyzed using the Chi-square test. *P* values of less than 0.05 were considered statistically significant.

Table 1. Demographic data

Parameters	Control group (N=20)	Rocuronium group (N=20)	*p* value
Age (year)	43.10 ± 10.63	43.10 ± 13.02	NS
Weight (kg)	54.25 ± 6.76	60.00 ± 14.81	NS
Height (cm)	158.10 ± 6.85	158.10 ± 7.34	NS
Sex (F/M)	8/12	12/8	NS
Duration of surgery (min)	47.00 ± 23.07	48.70 ± 25.30	NS
Tourniquet time (min)	60.30 ± 23.20	61.70 ± 25.48	NS

Values are shown as mean ± SD and ratio; NS indicates $p>0.05$.

Results

There were no differences between the two groups in the demographic data, i.e. age, weight, height, sex distribution, duration of surgery and tourniquet time (Table 1), as was the case with the onset and regression time of sensory block. Regarding the motor block, the onset time was significantly shorter and regression time significantly longer in the rocuronium group (group 2) ($p<0.001$, Table 2).

Quality of anesthesia was graded as excellent (grade 4) in all 20 patients of group 2, when compared with the 12 patients in group 1. ($p=0.344$), as six of them needed supplemental fentanyl intraoperatively. During the postoperative period in the recovery room, both groups needed supplemental fentanyl, and total fentanyl requirements were comparable (Table 3). There were no clinical side effects observed in either group throughout the study period.

Discussion

IVRA is a cost-effective, simple and safe method of providing anesthesia for minor upper limb procedures. One major drawback of the technique is the slow onset of motor block with poor muscle relaxation. Poor motor block may affect the operating conditions as well as the quality of anesthesia. During an operation, muscle stretch is a potent mechanical pain stimulus. The stretch transmission is associated with extracellular ATP and P2Y or P2X3 receptors. Total muscle relaxation abolishes muscle stretch and, therefore, reduces intraoperative pain and may prolong postoperative analgesia.

Many drugs have been added to local anesthetics during IVRA since this technique became popular in 1963. The main objectives are to improve the quality of anesthesia, decrease tourniquet pain and increase the length of postoperative analgesia. Achiving this includes the

Table 2. Onset and regression times of sensory and motor block

Parameters	Control group (N=20)	Rocuronium group (N=20)	*p* value
Sensory block onset time (min)	2.95 ± 1.22	2.75 ± 1.26	NS
Sensory block regression time (min)	3.10 ± 1.33	2.85 ± 0.85	NS
Motor block onset time (min)	26.00 ± 8.20	2.10 ± 1.09	<0.001
Motor block regression time (min)	2.20 ± 1.19	25.50 ± 10.37	<0.001

Value are shown as mean ± SD, NS indicates $p>0.05$.

Table 3. Quality of anesthesia and fentanyl requirement

Parameters	Control group (N=20)	Rocuronium group (N=20)
Quality of anesthesia		
Grade 1	0	0
Grade 2	6	0
Grade 3	2	0
Grade 4	12	20
Fentanyl requirement intraoperative (µg, mean±SD)	10.00 ± 17.01	0*
Fentanyl requirement Postoperative (µg, mean±SD)	25.00 ± 16.22	20.00 ± 15.38

*$p<0.001$ when compared with control group

use of opioids, ketamine, clonidine, dexamethasone, NSAIDs and muscle relaxants. McGlone et al [3] demonstrated that addition of 2 mg of atracurium improved muscle relaxation and prolonged analgesia. Esmaoglu et al [7] concluded that 0.01 mg/kg of cisatracurium added to lidocaine shortened the onset time of anesthesia, improved the quality of anesthesia and decreased postoperative analgesic requirements without causing clinical side effects. A non-depolarizing muscle relaxant blocks the function of the motor endplate, thus, neuromuscular transmission is more rapid on nerve conduction than the action of local anesthetics. This explains why the addition of muscle relaxant to local anesthetics shortens the onset time of anesthesia, particularly in motor block, while prolonged analgesia is likely due to less muscle stretch intraoperatively and less arm movement postoperatively.

Rocuronium is a steroidal non-depolarizing muscle relaxant with relatively fast onset. Since rapacuronium, another steroidal muscle relaxant with rapid onset, was withdrawn from the market in 2001, rocuronium has become the fastest muscle relaxant available for non-depolarizing onset in anesthetic practice. In this study, we showed that addition of 0.06 mg/kg of rocuronium to lidocaine solution for upper limb IVRA shortened the onset time of motor block and provided absolute analgesia intraoperatively, resulting in better quality of anesthesia. Although rocuronium provided prolonged motor block (25.50 min) after tourniquet release, there was no corresponding prolonged analgesia.

Although IVRA is found to be a safe technique, it may cause complications that fall into 2 major categories; local anesthetic toxicity and tourniquet related incidence. In addition, when a muscle relaxant is an adjuvant, one should be concerned also about its clinical effects after tourniquet release. Sztark et al [5] observed a transient diplopia after tourniquet release in patients under fentanyl with added pancuronium in IVRA. Torrance et al [8] reported that, under IVRA, patients in the 0.6 mg of mivacurium plus prilocaine group experienced some local anesthetic toxicity when compared with the control group (prilocaine alone), while the study of Louise et al [6] in which fentanyl and 1 mg of mivacurium were added to lidocaine, found no patients with local anesthetic toxicity or muscle weakness after tourniquet release. Whether a muscle relaxant affects the threshold of local anesthetic toxicity needs more investigation.

In this study, no patient encountered clinical side effects due to either rocuronium or lidocaine. In contrast to benzylisoquinolinium muscle relaxant, which undergoes Hoffman's degradation [10] rocuronium is not metabolized in the isolated limb and would be released into the systemic circulation after tourniquet release. However, 0.06 mg/kg is recommended as a

priming dose for rocuronium, and it should not cause clinical side effects such as diplopia, blurred vision or weakness. Although we did not find such side effects, one must emphasize that the use of a muscle relaxant could produce a clinical effect in an individual patient who is sensitive to a small amount of it. Another important side effect is local anesthetic toxicity. The 3 mg/kg dose of lidocaine used in IVRA is associated with maximum plasma concentrations of 1.5±0.2 μg/mL [9] which is considered safe. This recommended dose of lidocaine in conjunction with tourniquet release in a cyclic mode should provide the safe practice of IVRA. The technique of cyclic mode tourniquet release makes the time to reach peak concentration longer and the clinical symptoms of toxicity less common [9].

In conclusion, the addition of 0.06 mg/kg of rocuronium to lidocaine for upper limb IVRA shortened the onset time of motor block and improved the quality of anesthesia without significant clinical side effects or added cost. Although there was a prolonged motor block after tourniquet release, it did not correlate with prolonged analgesia.

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ผลของยาโรคูโรเนียมเมื่อผสมกับยาลิโดเคนในเทคนิคการระงับความรู้สึกเฉพาะส่วนแบบฉีดยาเข้าหลอดเลือดดำในการผ่าตัดบริเวณแขนและมือ

วรวุธ ลาภพิเศษพันธุ์, พ.บ.,[1] นุชนารถ บุญจึงมงคล, พ.บ.,[1] ศศิญา เรืองธนานนท์, พ.บ.[2]
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บทนำ เทคนิคการระงับความรู้สึกเฉพาะส่วนแบบฉีดยาเข้าหลอดเลือดดำ (intravenous regional anesthesia, IVRA) อาจมีการระงับความรู้สึกที่ไม่สมบูรณ์และกล้ามเนื้อหย่อนตัวไม่เต็มที่

วัตถุประสงค์ เพื่อศึกษาผลของยาโรคูโรเนียมที่ผสมในยาลิโดเคนต่อความไวของ sensory และ motor block เวลาหมดฤทธิ์ของ sensory และ motor block หลังคายสายรัด tourniquet คุณภาพของการระงับความรู้สึก และการระงับปวดหลังผ่าตัดในผู้ป่วยที่มารับการผ่าตัดบริเวณแขนหรือมือด้วยเทคนิค IVRA

วิธีการศึกษา ผู้ป่วยผู้ใหญ่ 40 ราย ที่มารับการผ่าตัดบริเวณแขนหรือมือตามตารางนัดหมายด้วยเทคนิค IVRA จะถูกสุ่มแบ่งเป็น 2 กลุ่ม กลุ่มที่ 1 ได้รับยาลิโดเคนขนาด 3 มก./กก. ขณะที่กลุ่มที่ 2 ได้รับยาลิโดเคนขนาด 3 มก./กก.ผสมกับยาโรคูโรเนียมขนาด 0.06 มก./กก. ยาที่ให้แก่ผู้ป่วยในทั้ง 2 กลุ่มถูกเจือจางในน้ำเกลือนอร์มัลเป็น 40 มล. บันทึกความไวของ sensory และ motor block เวลาหมดฤทธิ์ของ sensory และ motor block หลังคายสายรัด tourniquet คะแนน pain score และปริมาณยาแก้ปวดเฟนตานิลที่ผู้ป่วยได้รับระหว่างการผ่าตัดและในห้องพักฟื้น รวมถึงภาวะแทรกซ้อนที่พบหลังคายสายรัด tourniquet

ผลการศึกษา ในกลุ่มที่ 2 มีความไวของ motor block เร็วกว่า (2.10±1.09 เปรียบเทียบกับ 26.00±8.2 นาที $p<0.001$) และเวลาหมดฤทธิ์ของ motor block หลังคายสายรัด tourniquet นานกว่ากลุ่มที่ 1 (25.50±10.37 เปรียบเทียบกับ 2.20±1.19 นาที $p<0.001$) ในขณะเดียวกันพบว่าในกลุ่มที่ 2 ทุกรายมีคุณภาพของการระงับความรู้สึกดีมากและผู้ป่วยไม่ต้องการยาระงับปวดเพิ่มเติมในระหว่างการผ่าตัด ในห้องพักฟื้นความต้องการยาแก้ปวดเฟนตานิลในผู้ป่วยทั้ง 2 กลุ่มไม่แตกต่างกัน

สรุป การผสมยาโรคูโรเนียมกับยาลิโดเคนในเทคนิค IVRA สำหรับการผ่าตัดบริเวณแขนและมือ จะเร่งความไวของ motor block ทำให้การระงับความรู้สึกมีคุณภาพดีขึ้น โดยไม่พบอาการแทรกซ้อนที่ร้ายแรง **เชียงใหม่เวชสาร 2555;51(1):15-20.**

คำสำคัญ: เทคนิคการระงับความรู้สึกเฉพาะส่วนแบบฉีดยาเข้าหลอดเลือดดำ ยาหย่อนกล้ามเนื้อ ยาโรคูโรเนียม ยาชา ยาลิโดเคน