The Effects of Continuous Axillary Brachial Plexus Block with Ropivacaine Infusion on Skin Temperature and Survival of Crushed Fingers after Microsurgical Replantation

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Background: Continuous axillary brachial plexus block with local anesthetic has been shown to improve tissue perfusion after replantation surgery of the extremity. The present study aimed to investigate whether continuous axillary brachial plexus block with ropivacaine infusion can improve the survival of the reconstructive fingers secondary to an increase in its skin temperature in patients receiving replantation surgery of the crushed fingers.

Methods: Under general anesthesia, 18 patients received replantation or toe-to-hand transplantation of their crushed digits. They were randomly divided into two groups. Under ultrasound guidance, continuous axillary brachial plexus analgesia was effected by a loading dose of 10 ml 0.75% ropivacaine, followed by an infusion of 4-5 ml per hour for up to three days (Group A). Patients who did not receive continuous analgesia postoperatively served as a control (Group B). An infrared thermometer was used to hourly assess the skin temperature of the surgical and non-surgical sites in both groups for 24 h after the surgery. In addition, the survival (the rate of re-operation or amputation) of the reconstructive digits was also evaluated in both groups.

Results: The skin temperature of the digits (T1) on both groups did not show any significant difference at any point of time after the surgery albeit there was a trend of increased skin temperature on the reconstructive digits in patients receiving continuous axillary brachial plexus block (Group A) as compared to those without receiving the block (Group B). Also, the difference in skin temperature (dT) differed slightly at 0, 9 and 21 hours postoperatively in Group A in comparison with Group B (0.75 ± 0.65 vs. -2.33 ± 1.24, 0.53 ± 0.34 vs. -3.02 ± 1.27, -0.125 ± 0.55 vs. -2.33 ± 0.91, $p < 0.05$). However, no patients in both groups received a second operation or amputation of the graft.

Conclusions: The result of this study demonstrated that axillary brachial plexus block with continuous infusion of 0.75% ropivacaine can increase the skin temperature, an index of tissue perfusion, of the reconstructive digits for 24 h after microvascular surgery of the crushed fingers. However, graft survival was good in both groups.

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Axillary approach for brachial plexus block has been widely accepted for surgery of the upper extremity because of fewer complications.[1-5] This technique is especially useful when microvascular surgery such as replantation of digits are needed since continuous provision of this block after the surgery is beneficial in preventing postoperative vasospasm of the reconstructive tissue. In addition to the continuous monitoring of the skin color and temperature of the reconstructive part, other factors such as less complicated wound, easy identification of neurovascular structures, adequate perfusion to the replantation site, and less extent of infection are likely to improve the survival of the graft.[6]

Because skin temperature is an important index for the evaluation of the graft, the present study aimed to compare skin temperature of the graft in patients receiving continuous axillary brachial plexus block with those who did not receive this treatment. We also evaluated whether continuous axillary brachial plexus block can improve the survival of the graft.

METHODS

This prospective randomized study was approved by the Institutional Review Board of Chang Gung Memorial Hospital, and the written informed consent was obtained from the patients through September 2003 to May 2004. We enrolled eighteen patients with ages ranging from 19 to 49 years-old who suffered from cutting or crushing injury of fingers. These patients underwent a microsurgical technique for finger replantation or toe-to-hand transplantation. They were randomly divided into two groups based on computer-generated random numbers. Patients in Group A (aged 30.8 $\pm$ 7.7 yr, n = 9) received continuous axillary brachial plexus block, while patients in Group B (aged 36.8 $\pm$ 12 yr, n = 9) did not receive the treatment which served as a control. Patients with preexisting systemic disease such as hypertension, diabetes mellitus, cardiovascular disease, coagulopathy, and nephropathy were excluded from this study.

Anesthesia was induced with thiopental sodium (4 mg/kg, i.v.), and endotracheal intubation was facilitated by rocuronium bromide (1 mg/kg, i.v.). Anesthesia was maintained by sevoflurane (end-tidal concentration of 2%) or desflurane (6%) in 100% oxygen. Under general anesthesia, the patient was positioned supine with the arm abducted at 90 degrees and flexed at the elbow. The axillary artery was identified and marked in the upper portion of the groove between the biceps and triceps muscles.[1] After aseptic preparation, 1% lidocaine 2~3 ml was injected subcutaneously in close proximity to the ulnar side of the artery. Under ultrasound guidance (L38 10-5 MHz transducer, Sonosite Titan System, Bothell, WA, USA) and a nerve stimulator (Simplex Dig RC B. Braun Belsungen AG), an 18-gauge needle (18G, Port Ltd, UK) was inserted into the fascial sheath of the axillary plexus. A catheter (20G, Port Ltd, UK) was then advanced 15 cm in depth beneath the skin. After securing the catheter to the skin by adhesive tapes, patients in Group A received a loading dose of 10 ml 0.75% ropivacaine, followed by a maintenance dose of 4~5 ml/hr throughout the perioperative period for up to 3 days.

The skin temperature of the surgical side (T1) and the contralateral (non-surgical) side (T2) of both hands was measured hourly using an infrared non-contact thermometer (Raytek, Raynger MX, RAYMX, Germany) after the injection of ropivacaine, and was continuously monitored when the patient was sent to and remained in the microsurgical care unit. The visual analog pain scale was determined postoperatively for 24 hours in the evaluation of the analgesic effect of this block.[7,8]

The patient was extubated in the operation room, and sent to the microsurgical care unit for further management. To enhance the blood flow to the grafts, Dextran (Dextran-D 500 ml 2~4 g/kg) and PGE_1 (Alprostadil 5~10 ng/kg/min, qd > 2 hr) were routinely administered to all patients. The perfusion of the grafts including skin color, turgor and capillary refilling were evaluated, and were graded according to the following scores as shown in Table 2. A radar graph was also used to illustrate the effect of continuous axillary block on the perfusion of the grafts in both groups (Fig. 3). Good survival was defined as a

graft that did not need a second operation or amputation.

Data are presented as mean ± SD. Statistical analysis was assessed by unpaired *t*-test with Welch's correction using the GraphPad Prism4 program. $p < 0.05$ was considered significant.

RESULTS

The demographic data are shown in Table 1. There were no significant differences between the two groups except the number of female patients that were outnumbered by their counterpart in a ratio of 1 to 17. Three patients in Group A received toe-to-hand transplantation while the others in both groups received finger replantation. Three patients (2 in Group A, 1 in Group B) suffering from crush injury of more than one digit received replantation surgery for the injured fingers. The temperature was recorded for all reconstructive digits.

The surface temperature of the reconstructive digits (T1) was slightly higher in patients receiving continuous axillary block compared to those without receiving this treatment, but was not statistically significant from the 3rd hour to the 24th hour postoperatively (Fig. 1). The maximal difference of T1 between two groups was 2.6°C occurring at the 20th hour after the surgery. Compared to Group B, the difference between the surface temperature of the reconstructive site and contralateral non-surgical site (dT = T1 - T2) was greater in Group A (0.75 ± 0.65 vs. -2.33 ± 1.24, 0.53 ± 0.34 vs. -3.02 ± 1.27, -0.125 ± 0.55 vs. -2.33 ± 0.91, $p < 0.05$, Fig. 2). Significant difference in dT was found immediately (the 0 hour), 9 hours and 21 hours after the surgery. It is also interesting to note that the dT in some patients of both groups was negative, indicating that the temperature of the reconstructive site was lower than the contralateral non-surgical site despite of the continuous axillary block.

Patients in Groups A experienced a good postoperative analgesia with a reduction in VAS (visual analog scale) from 8 to 2.[7-10] The satisfactory pain relief in these patients was accompanied by paresthesia and numbness of the extremities after ropivacaine injection. Patients in the control group were not assessed in terms of paresthesia and numbness of the extremity because other analgesics were given when appropriate.

The stay in microsurgical care unit did not significantly differ in these two groups (4.6 ± 4.03 days in Group A versus 4.2 ± 2.16 days in Group

Table 1. Demographic Data

	Group A (Axillary blockade)	Group B (Non-axillary blockade)	*p*-value*
Age (y/o)	36.8 ± 12	30.8 ± 7.7	0.3715
Gender (male / female)	8 / 1	9 / 0	
Weight (kg)	67.5 ± 7.9	69.4 ± 4.2	0.6248
Total dose (ml) of 0.75% ropivacaine†	155 ± 19.2	None	
microsurgery care unit stay (day)	4.6 ± 4.03	4.2 ± 2.16	0.8224
Total hospital stay (day)	13.3 ± 5.64	16 ± 14.3 (max. 40 days)	0.6825

* by Student's *t* test

† from the beginning to the first 24 hours

Table 2. Scores for the Assessment of the Graft's Perfusion

Scores / parameters	1	2	3	4
Skin color (1~4)	Pale / White	Blue / purple	Deep red	Pink
Capillary refill (1~4)	Absent	Sluggish > 2 sec	Fast < 1 sec	Brisk 1~2 sec
Turgor (1~3)	Flat	Bulging	Full / soft	

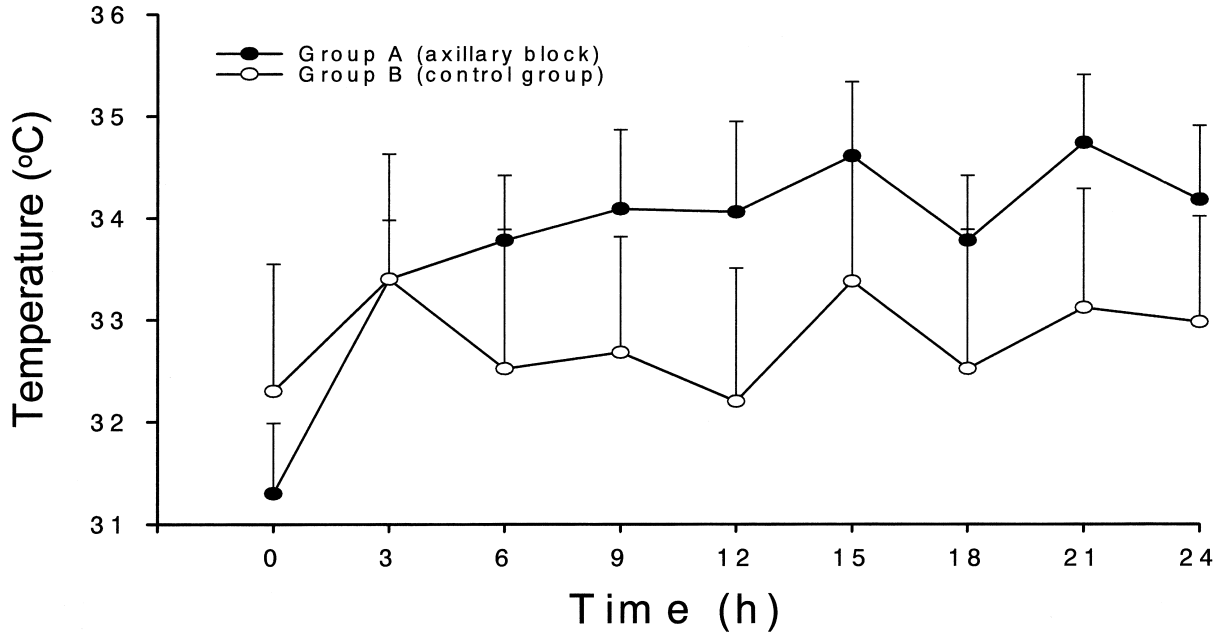

Fig.1 The T1 of Group A and Group B in the first 24 hours postoperatively. T1 represents the surface temperature of the reconstructive digits.

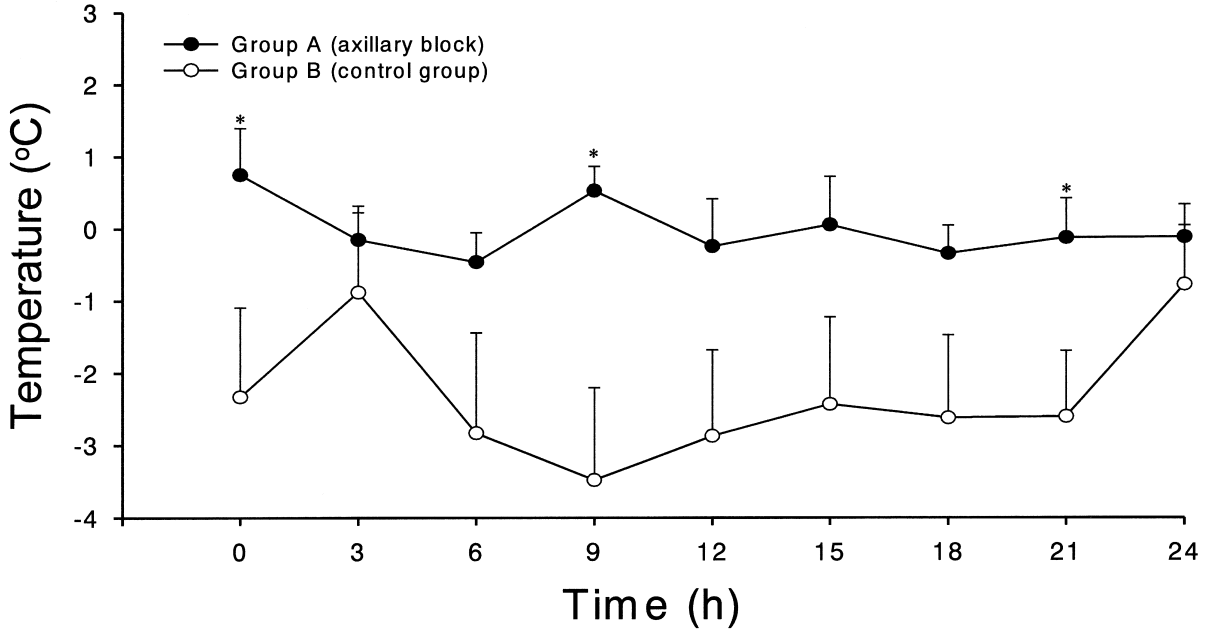

Fig. 2 The dT of Group A and Group B in the first 24 hours postoperatively. The dT was calculated by the subtraction of the temperature of the reconstructive site (T1) minus the temperature of the opposite non-surgical site (T2). * $p < 0.05$ by unpaired *t*-test with Welch's correction.

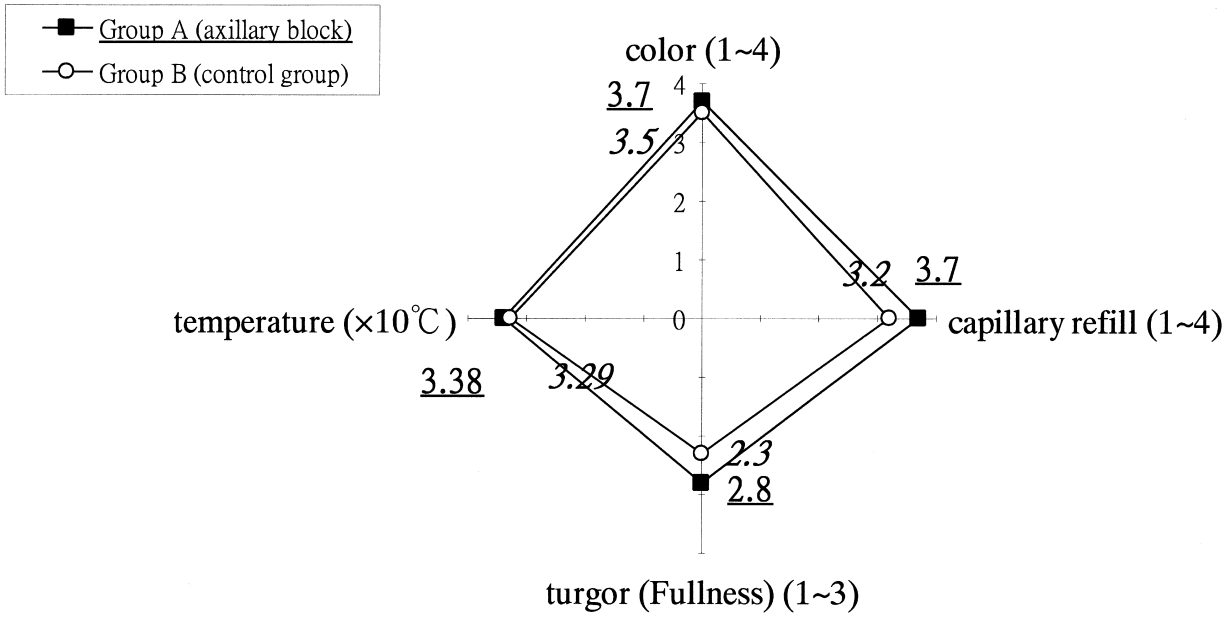

Fig. 3 Radar illustration of the Graft's perfusion

B). Similarly, the total days of the hospital stay did not significantly differ between both groups (13.3 ± 5.64 days in Group A versus 16 ± 14.3 days in Group B, Table 1). No patient in both groups suffered from postoperative ischemic change of the replanted digits, and no one needed a second operation for the reconstruction of vessels.

DISCUSSION

Continuous axillary brachial plexus block has shown a beneficial effect following microvascular reconstruction surgery. This technique provides adequate blood supply because of its sympatholytic effect, which in turn avoids vasospasm for vessels with possible compromised circulation.[11-13] In addition, it is able to offer satisfactory pain relief postoperatively.[2,4,13] To improve survival of the graft after finger replantation, it is important to carefully monitor the temperature, color and turgor of the skin, as well as the capillary refilling of the reconstructive digits. It is also critical to provide patients with appropriate anticoagulants, adequate hydration and normal body temperature.[2] Good outcome can be predicted if the following conditions are observed in the graft after surgery: (a) skin color manifests pink rather than deep-red, blue, or even pale; (b) capillary refilling is brisk (1~2 sec); (c) skin turgor is soft; and (d) skin temperature is at or above 31°C.

Temperature measurement has become the most commonly used method for the observation of the vascular perfusion. A decrease in vascular flow results in a reduction of the skin temperature of the fingers. A higher temperature indicates a better arterial flow into the replanted digits. Any change in the vascular perfusion can be detected early based on the difference between the temperatures of these fingers.[2] The result of the present study was in line with our suggestion that continuous infusion of ropivacaine in brachial plexus block can provide better circulation to the replanted digits. Axillary brachial plexus analgesia obviously prevents the development of vasospasm in the replanted digits after replantation.[11,13,14] It is interesting to note that the dT value in most patients was negative in both groups. This manifestation can be explained by the fact that the injured vascularity of the reconstructive digits appears to give a poor peripheral perfusion than those in the non-injured counterpart, resulting in a lower temperature in this region. Patients without brachial plexus analgesia obviously demonstrate impaired circulation, and poor outcome might then

be predicted.

Whatever continuous axillary brachial plexus analgesia was given, the outcome of our patients in both groups was relatively good, albeit monitoring the skin temperature of the reconstructive digits was able to predict prognosis. The duration of stay in the microsurgical care unit and the hospital is also similar. Functional rehabilitation was successfully given to these patients several days after the surgery. Confounding factors such as status of the injured parts, patients' medical condition, duration of the injury, and surgical technique will all affect this similar outcome. The above factors result in difficulty drawing a conclusion that the axillary brachial plexus block can improve the graft survival. The inadequate size of the patient sample is also a limitation of our study.

Complications such as localized infection, hematoma, retained catheter fragment, paresthesia, and drug toxicity were commonly reported during continuous axillary brachial plexus block.[3,4,15-17] Several lines of evidence demonstrated that the neurological complications between single-dose injection and continuous infusion for axillary brachial plexus blockade were similar.[4,17] In our study, there was no peripheral neuropathy found in patients receiving the block. Patients who suffered from paresthesia, numbness and limitation in arm movement suffered only for a short period, and recovered soon after the axillary block was discontinued. This phenomenon is contributable to the high concentration of the ropivacaine infusion. Lowering the drug concentration is expected to reduce the incidence of paresthesia and numbness of the extremity. Ultrasound-guidance in performing the block has shown to be useful in the identification of the axillary artery, which can avoid the malpositioning of the catheter during needle puncture.[18] Using a nerve stimulator in performing the block in patients under general anesthesia was not as effective as in peripheral nerve block in conscious patients because patients were paralyzed by muscle relaxant during general anesthesia. Therefore, ultrasound guidance can avoid complications such as accidental damage of the nerves during the procedures.

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手指顯微重建手術時以持續注射 Ropivacaine 做連續腋下神經叢阻斷對壓傷手指的表面溫度及存活率的影響

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背 景： 持續注射局部麻醉藥做臂神經叢阻斷術，可改善重建手指組織的溫度，進而增加存活率。本研究旨探討持續以 ropivacaine 做腋下神經叢阻斷術時，對接受重建手術的病人可增加重建手指溫度及其存活率。

方 法： 18 位病人皆因手指切割或壓碎傷接受手指重植的顯微手術。病人隨機分配爲實驗組（A 組）與對照組（B 組）。A 組於全身麻醉後放置導管於腋下神經叢內，並以 0.75% ropivacaine 持續滴注。利用紅外線溫度儀，測量兩組病人重建處及健康側手指表面溫度的變化並紀錄之，同時評估其存活率（是否重覆手術或截肢）。

結 果： 兩組病人手指重建處溫度 (T1) 沒有明顯差異，雖然 A 組的溫度稍高於 B 組，但無統計上的意義。另外，患側與健側手指溫度差 (dT) 在術後第 0，9，21 小時有明顯統計上的差異。存活率方面，兩組皆無病人接受再次手術或截肢。

結 論： 由本研究推論，以 0.75% ropivacaine 做連續腋下神經叢阻斷術，可以增加重建手指的表面溫度，手指溫度爲重建組織灌流血行的指標。但兩組的組織存活率皆良好，沒有差異。

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關鍵字： 手指重建，顯微手術，連續腋下神經叢阻斷術，Ropivacaine，表面溫度，存活率。

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