Regional haemodynamic changes after selective block of the four principal nerves in the arm

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Regional Hemodynamic Changes after specific block of the musculocutaneous, radial, ulnar, or median nerves in the upper extremity: a double blind randomised controlled study

Abbreviated Title: Hemodynamic changes after nerve block

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Abstract

BACKGROUND Sympathetic blockade produced by brachial plexus blockade (BPB) can lead to vasodilatation in the upper limb but specific nerve innervation of the radial and ulnar artery is unclear.

OBJECTIVES To delineate which specific nerve blockade would lead to an increase in the blood flow of radial or ulnar arteries.

DESIGN A blinded randomized controlled trial

SETTING The Second Affiliated Hospital & Yuying Children hospital of Wenzhou Medical University, Wenzhou, China from March to December 2012

PATIENTS Thirty-two patients undergoing upper extremity surgery were randomized to 4 equally sized groups: Group MC (musculocutaneous), Group UL (ulnar), Group RA (radial) and Group ME (median).

INTERVENTIONS Patients received specific nerve block according to group allocation followed by axillary BPB. Hemodynamic changes, cross-sectional area (CSA) and skin temperature were measured. Sensory blockade was assessed.

MAIN OUTCOME MEASURES Change of blood flow (δBF).

Results In the radial artery, Group ME has the highest change in δBF (versus Group RA, $P<0.05$; versus Group MC and Group UL, $P<0.05$), followed by Group RA (versus Group MC and Group UL, $P<0.05$). No significant changes were seen in Group MC and Group UL ($P>0.05$). In the ulnar artery, δBF in Group UL was significantly higher than the other three groups ($P<0.05$). No significant changes were seen in Groups MC, ME and RA ($P>0.05$).

Conclusions—Ulnar nerve block resulted in arterial vasodilatation, increased blood flow and velocity in the ulnar artery. Median nerve block resulted in arterial vasodilatation, increased

blood flow and velocity in the radial artery. Radial nerve block only resulted in modest increased blood flow in the radial artery. There were no interaction between the haemodynamics of ulnar artery and radial artery.

Clinical trial registration: ClinicalTrials.gov identifier: NCT02139982.

Introduction

In upper limb vascular reconstruction surgery, radial, ulnar arteries and their branches are common donor or recipient vessels. Brachial plexus block (BPB) is a widely used regional anesthetic and analgesic technique for this surgery. The resultant sympathetic nerve block can lead to vasodilatation, increase in blood flow and skin temperature in the ipsilateral upper limb,[1-3] which has been used to treat severe forearm ischemia after arterial cannulation.[4,5] The vasodilation and increased blood flow of radial or ulnar arteries could be beneficial for survival of transplant in vascular reconstruction.

Traditional anatomical textbooks demonstrated arteries in the upper limbs were innervated by a number of branches of nerves.[6,7] At the level of the axilla, the sympathetic nerves innervating the radial and ulnar artery travel with the brachial plexus. However, it is unknown which specific nerve among musculocutaneous, radial, ulnar, and median nerves innervates radial or ulnar artery. In experienced hands, ultrasound guided peripheral nerve blockade can visualize musculocutaneous, ulnar, radial and median nerves and block them separately with local anesthetic with accuracy.[8] We therefore conducted a randomized controlled trial to delineate which specific nerve blockade would lead to an increase in the blood flow of radial or ulnar arteries.

Materials and Methods

This double-blind randomized controlled study was conducted in，China (single site). Study approval was obtained from the Institutional Review Board (IRB) of the Second Affiliated Hospital & Yuying Children hospital of Wenzhou Medical University (109 Xueyuang xi Road, Wenzhou, China, Ref 2009(002), February 2th, 2009, Prof. Qinquan Lian), and was registered at Clinicaltrials.gov with the identifier NCT02139982 on 28 May 2014. The principal investigator is Ting Li. Between March and December 2012, all consecutive adults undergoing upper extremity surgery were screened for the trial. Inclusion criteria were adults (>18 year-old), ASA (American Society of Anesthesiologists) Classification I-III and elective surgery. Exclusion criteria were infection at the site of needle insertion; coagulopathy defined as international normalised ratio >1.4 or, platelet count $<80\times10^9$ $litre^{-1}$; allergy to local anaesthetics; peripheral neurological disease, or peripheral vascular disease.

Informed consent was obtained from each patient on the day before operation. Patients were randomly assigned to 4 groups according to the specific nerve blockade (SNB) of brachial plexus: Group MC (musculocutaneous), Group UL (ulnar), Group RA (radial) and Group ME (median) using computer (Microsoft excel 2010) generated random number in sealed envelopes.

The nerve blockade was performed in the recovery room with room temperature of 24 °C. Each patient lay supine in a hospital bed in a hospital gown and standard monitoring (NBP, continuous ECG, and pulse oximetry) was initiated before start of procedure. All nerve blocks were performed by one experienced consultant anesthetist with 8 year experience in ultrasound-guided nerve blockade. A separate study investigator, who was blinded to the protocol and patient allocation, completed the study hemodynamic measurements at all time points: before insertion of blockade (baseline, t_0), at 30min after SNB (t_1), at 30min after whole BPB (t_2). Study measurements were hemodynamic changes and cross-sectional area (CSA) of ulnar and radial artery and skin temperatures of the innervated areas. Heart rate (HR) and Mean arterial pressure (MAP) were recorded simultaneously.

The insertion of Specific Nerve Blockade and Brachial Plexus Blockade

Patients' arm was abducted 90 degrees from the body with the elbow flexed. After skin disinfection, the allocated specific nerve of brachial plexus (MC, UL, RA, ME) was blocked in the axillary region by using ultrasound combined with neurostimulation. The specific nerve was identified in axillary region using a high-frequency linear ultrasound transducer (HFL 38X/13-6 MHz, S-nerve TM Ultrasound System, SonoSite Inc., Bothell, Washington, USA). Using in-line technique, nerve stimulation needle (Stimuplex® D, 22G, 50mm; B.Braun Melsungen AG, Germany) was inserted and placed the needle tip close to the nerve with electric impulses (2 Hz, 0.5 mA, 0.1 ms) of nerve stimulator (Stimuplex® HNS 11 Peripheral Nerve Stimulator, B.Braun Melsungen AG, Germany). Visible contraction of the innervated muscle was used to confirm this specific nerve. Then 5 ml ropivacaine 0.5% (Naropin, Astra- Zeneca, Sweden) was injected, ensuring local anesthetic was distributed circumferentially around the nerve with ultrasound. At 30min after SNB when all study data were captured, all patients receive scheduled axillary BPB (total 30ml ropivacaine 0.5%) for surgery. The other three nerves of axillary BPB were blocked with the same method as SNB. The proportion of the volume injected in each nerve was at the discretion of the expert operator according to the spread of local anesthetic. If required, routine general anesthesia or sedation was given.

Block assessment

Sensory blockade was assessed by pinprick sensation (22G needle) and compared with the opposite forearm or hand for normal, hypoesthesia or no sensation. Success of SNB was defined as loss of sensation in the cutaneous distribution of the specific nerve (musculocutaneous, ulnar, radial, or median nerves) at 30min after SNB. If hypoesthesia or no sensation was detected in the innervation areas of any other nerve, the patient was excluded. Success of BPB was defined as the absence of sensation in all innervation areas of above four nerves 30min after the BPB.

Measurement of hemodynamic parameters

For the measurements of hemodynamic parameters, patient's forearm was placed in supination with a pillow placed under the wrist. The ulnar artery and radial artery were located at 1 cm proximal to the ulnar or radial styloid process. Specific points were located with skin marker to provide consistency for all measurements. Hemodynamic parameters were measured by Pulsed-wave Doppler (PWD) ultrasound (DC-6, Mindray Medical International Limited, China) with a 7L4 linear array transducer (frequency 10 MHz). The probe was placed on the ventral wrist parallel to the long axis of the forearm without undue pressure on the artery during the PWD measurements. The volume gate was positioned in the center of the arterial lumen, and the size of the gate was 1/3 lumen of the artery. The angle of insonation was adjusted and maintained at 50-60 degrees. Once a desired PWD spectral waveform was achieved, the arterial hemodynamic parameters were recorded. These parameters included peak systolic velocity (PSV, cm/s), end-diastolic velocity (EDV, cm/s) and time average maximum velocity (TAMAX) (Fig 1).

Measurement of artery area and blood flow

The cross-sectional area (CSA) of the artery was assessed with B-mode imaging. Probe was kept perpendicular to the long axis of the artery to obtain the largest oval arterial section. The image at end diastole was chosen and measured with the cine loop. The changes in arterial cross-sectional area during the cardiac cycle were not measured in this study. Blood flow (BF) was calculated by formula BF = TAMAX× CSA×60s. Relative change in regional blood flow was calculated by: $\delta BF = (BF_{t1} - BF_{t0}) / (BF_{t2} - BF_{t0})$.

Measurement of skin temperature

Using the rapid precise contact thermometer (DAE-905T, ShengGao Inc., China), skin temperature (T_s) was measured at four different points within the cutaneous innervation areas of the musculocutaneous (lateral skin of forearm, T_sMC), ulnar (hypothenar region, T_sUL), radial (thumb-index web, T_sRA) and median (thenar, T_sME).

Statistical Analysis

Sample size was calculated based on results obtained from our pilot study that showed the mean (SD) radial and ulnar artery blood flow, our primary outcome variable, increased 3-fold (33.3± 19.5 to 102.1±54.5 mL/min) when measured 30 minutes after SNB or BPB(unpublished data). Six patients were required in each group to give the study power of 80 % (*P<0.05*). To allow for equipment failure, we recruited 8 patients to each group. SPSS for Windows 16.0 (SPSS Inc, Chicago, USA) was used for statistical analysis. Categorical data were presented as numbers and were compared using the Chi-square test or Fisher's exact test as appropriate. Continuous data were presented as mean (SD) or median (IQR). For each parameter, the measurements at different time points were compared for interaction in repeated measures analysis. Relative change in regional blood flow was compared by Kruskal-Wallis H non-parametric test among different group. For all tests, statistical significance was defined as a p value < 0.05.

Results

The subjects approached are summarized using a CONSORT flow diagram (Figure 2). Finally, thirty-two patients were randomized into the study. All patients were undergoing elective surgery (13 removal of metalwork from ulnar/radial, 7 fixation of fractured metacarpal, 6 fractured phalanx and 4 surgical removal of soft tissue mass). Two patients were excluded due to SNB failure (one is median, the other is ulnar), leaving 30 patients who completed the study. There was no significant change detected in patient's characteristics, the heart rate and blood pressure after the SNB and after BPB across the four groups (Table 1).

Changes in regional hemodynamic parameters in the radial and ulnar arteries were summarized in Table 2 and Table 3. There was no significant difference in each hemodynamic parameter at baseline (t_0) among four groups. Significant increases in TAMAX, BF of radial artery in Group RA and PSV, EDV, TAMAX, CSA, BF of radial artery in Group ME were seen 30min after SNB (t_1) comparing with t_0 (P<0.05). There was also a significant increase in PSV, EDV, TAMAX, CSA, BF of ulnar artery in Group UL at t_1 comparing with t_0 (P<0.05). There changes were not seen in Group MC and in other parameters in Groups RA, UL, ME 30min after SNB (t_1) comparing with t_0 (P>0.05). Compared with t_1, most of parameters were increased significantly in four Groups at t_2 (P<0.05), except for EDV, CSA of radial artery in Group ME and CSA of ulnar artery in Group UL (P>0.05).

Relative changes in regional blood flow were shown in Figure 3. The greatest relative change of blood flow in the radial artery was in Group ME (P<0.05). The changes in the Group RA were less (P<0.05) and furthermore there were no significant changes in Group MC and Group UL (P>0.05). Relative change of blood flow of ulnar artery in Group UL was greater than the other three Groups (P<0.05). The changes among groups MC, ME and RA were not seen (P>0.05).

In terms of skin temperature (Ts), there was a significant increase in T_s UL in Group UL and in T_sME and T_sRA in Group ME at t_1, comparing with t_0 ($P<0.05$) (Table 4). There were no changes in T_s of cutaneous innervation areas of four nerves in Group MC and RA, and in T_s of cutaneous innervation areas of the other nerves in Group RA and Group UL at t_1, comparing with t_0 ($P>0.05$). Compared with t_1, most of T_s of cutaneous innervation areas of four nerves in four groups were increased significantly in four groups at t_2 ($P<0.05$), except for T_s UL in Group UL ($P>0.05$).

Discussion

In our study, the median nerve block resulted in a substantial increase in PSV, EDV, TAMAX, CSA and BF (nearly 3-fold) of radial artery. Radial nerve block resulted in an increase in TAMAX and BF (less than 2-fold) of radial artery; ulnar nerve block resulted in a substantial increase in PSV, EDV, TAMAX, CSA and three-fold increase in BF of ulnar artery; musculocutaneous nerve block did not change any hemodynamic parameters of ulnar and radial artery. The increased CSA in our study was a direct result of vasodilatation. Our study data showed that radial artery may be innervated by median nerve only and not by radial nerve; whereas ulnar artery is innervated by ulnar nerve only at the level of axillary region. Our results appear to contradict previous anatomical studies in forearm region that demonstrated that the radial artery receives branches from the median nerve, [6] superficial branch of the radial nerve or lateral antebrachial cutaneous[7] and ulnar artery receives a branch of the ulnar nerve.[6] The exact pathway of sympathetic innervation to the radial artery remains unclear and further research is required.

From our data, median nerve block resulted in a greater increase in blood flow of radial artery than radial nerve block and only ulnar nerve block increased blood flow of ulnar artery (Fig 3). Therefore, we believe that the increases in blood flow and reduction in peripheral vascular resistance reported after BPB in the previous studies was a reflection of successful median and ulnar nerve block mainly. Blocking median or ulnar nerve specifically may be beneficial for microvascular surgery with vasodilatation and increased blood flow. A study by Baddal et al found that median nerve block resulted in a significant increase in PSV, but no changes in diameter of radial artery was detected.[9] However this could be due to the fact that many patients of their study had risk factors of peripheral vascular disease. Another difference was that we elected to block specific nerve at the axillary region and as opposed to blocking at the level of anterior elbow.

Vascular steal is a well-documented phenomenon in the surgical literature, commonly known as "steal phenomenon". Van's case report presented the steal phenomenon, a marked drop in blood flow in a second toe-to-hand transfer with the vasodilatation of the hand and forearm after axillary plexus block.[10] Sonntag reported three cases of lower extremity reconstruction using microvascular free tissue transfer in which the free flap survived but the distal extremity suffered progressive ischemic necrosis.[11] In our study, the increased blood flow in radial or ulnar artery did not result in decreased blood flow of the other artery, no steal phenomenon. The palmar arcuate arteries may be one of reasons why steal phenomenon probably did not occur patients without history of peripheral vascular disease. However exact mechanisms behind steal phenomenon had not been fully elucidated. Further studies are needed to clarify whether the steal phenomenon happens in the patient undergoing vascular reconstruction or with vascular disease after an incomplete BPB (only non-surgical side block).

In our study, BPB resulted in a further increase in majority of hemodynamic parameters comparing with SNB. There are several possible explanations for this result: (1) the effect of sympathetic block strengthened as the extension of time after SNB. (2) BPB further reduced the distal PVR. (3) Other branches of the brachial plexus besides the four nerves were blocked by BPB. However, we did not see a further increase in the CSA of radial artery in Group ME and the CSA of ulnar artery in Group UL after BPB. This provided further proof that the vessel walls of radial artery and ulnar artery are only innervated by median nerve and ulnar nerve respectively.

In this study, we also found that the specific ulnar and median nerve blocks resulted in a substantial increase of temperature (Ts) in the areas innervated by these nerves. Of note, the specific median nerve block resulted in an increase of T_S in the area innervated by the radial nerve. The specific musculocutaneous or radial nerve block did not increase T_S of any area. Our results agree with previous published findings.[12] The phenomena could be explained by the sympathetic nerve block causing the reduction PVR and the increase of BF.[13] Specific radial nerve block increased the BF of radial artery to some extent, but did not increase the T_s in the areas innervated. Our findings support the theory that the skin on the radial aspect of the dorsum of the hand (sensation innervated by radial nerve) is provided vasomotor innervation by the median nerve as demonstrated by previous research.[12 14] Therefore, the radial nerve may supply vasomotor innervation to the underlying tissues but not the skin of the radial aspect of the dorsum of the hand. The resultant increase in BF may be too little to raise T_s significantly or period of measurements may be too short to find the increase T_s after specific radial nerve block. Overall, the changes of T_s are coincident with the haemodynamic changes of radial and ulnar artery after SNB.

Currently, PWD ultrasound is common method to measure the haemodynamic changes in the upper extremity.[15] The authors took many steps to minimize measurement errors, including controlling the ambient temperature and humidity; having all measurements performed by a single investigator; using a standardized measurement of PWD ultrasound and marking the position of measurement. However, this study suffers from some limitations. Firstly, we only observed measurements for 30 minutes after SNB and BPB to avoid delay in operating schedule. As a result, peak changes of hemodynamics and T_s may not be represented in this study. Secondly, we elected to perform SNB at the axillary region where the four major nerves have no branches, a location more proximal site than that in previous studies.[9 12] The median, ulnar and radial nerves lie closely together in the axilla. We cannot exclude the possibility of local anesthetic spread due to close proximity of nerves, so SNB in this study may not be as reliable as that those performed at more distal anatomy sites. But we have tried to minimize this effect by using an experienced operator and the ultrasound combined nerve stimulator. Considering popularity of the axillary approach to the brachial plexus,[16] and beneficial effect of the continuous axillary BPB,[17 18] our results from axillary BPB may have clinical significance in microvascular reconstruction surgery.

Future clinical studies should address whether continuous SNB has more benefit for microvascular reconstruction surgery than routine continuous BPB.

In conclusion, specific ulnar and median nerve block resulted in arterial vasodilatation, an increase in blood flow velocity and in blood flow of ulnar artery and radial artery respectively. Specific radial nerve block resulted in only slight increase in blood flow of radial artery. Specific musculocutaneous nerve block did not change the hemodynamics of ulnar and radial artery. The hemodynamics of ulnar artery and radial artery did not interact with each other. Whether single injection or continuous axillary block is to be used for microvascular hand surgery, median and ulnar nerves are the most two important nerves that need to be blocked completely.

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Conflict of interest: none.

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Figure 1 Pulsed-wave Doppler Ultrasound of the radial artery after specific median nerve blockade. PS: peak systolic velocity (PSV, cm sec.-1), ED: end-diastolic velocity (EDV, cm sec.-1), TAMAX: time average maximum velocity (cm sec.-1)

Figure 2 The CONSORT flow diagram for randomized controlled trials.

Figure 3 Box-and-whisker plots of relative changes in blood flow across the four groups. Values were presented by median, IQR and range.

* $P<0.05$ compared with other three groups, # $P<0.05$ compared with Group MC

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CONSORT flow diagram (for publication as a figure)

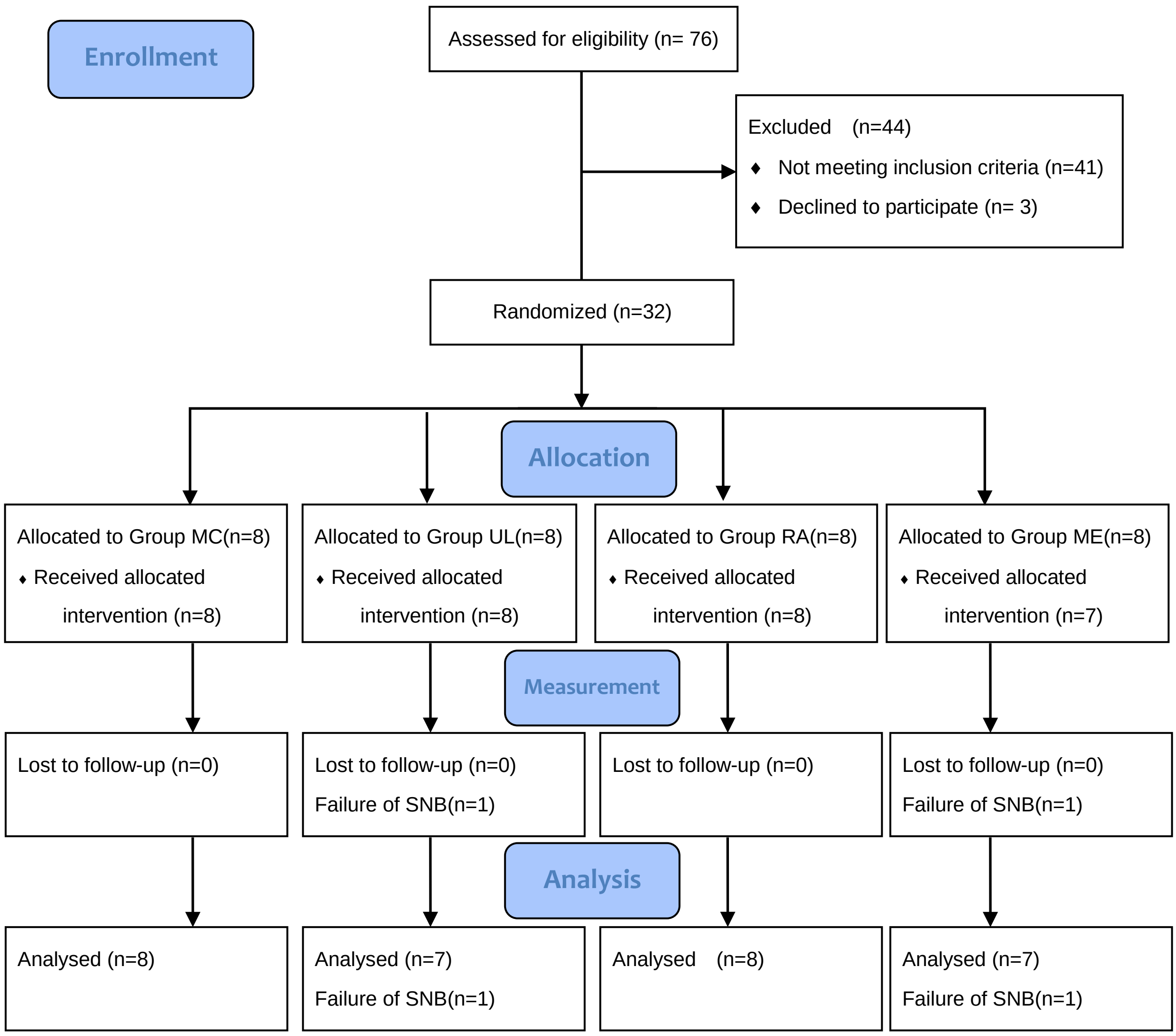

Figure1

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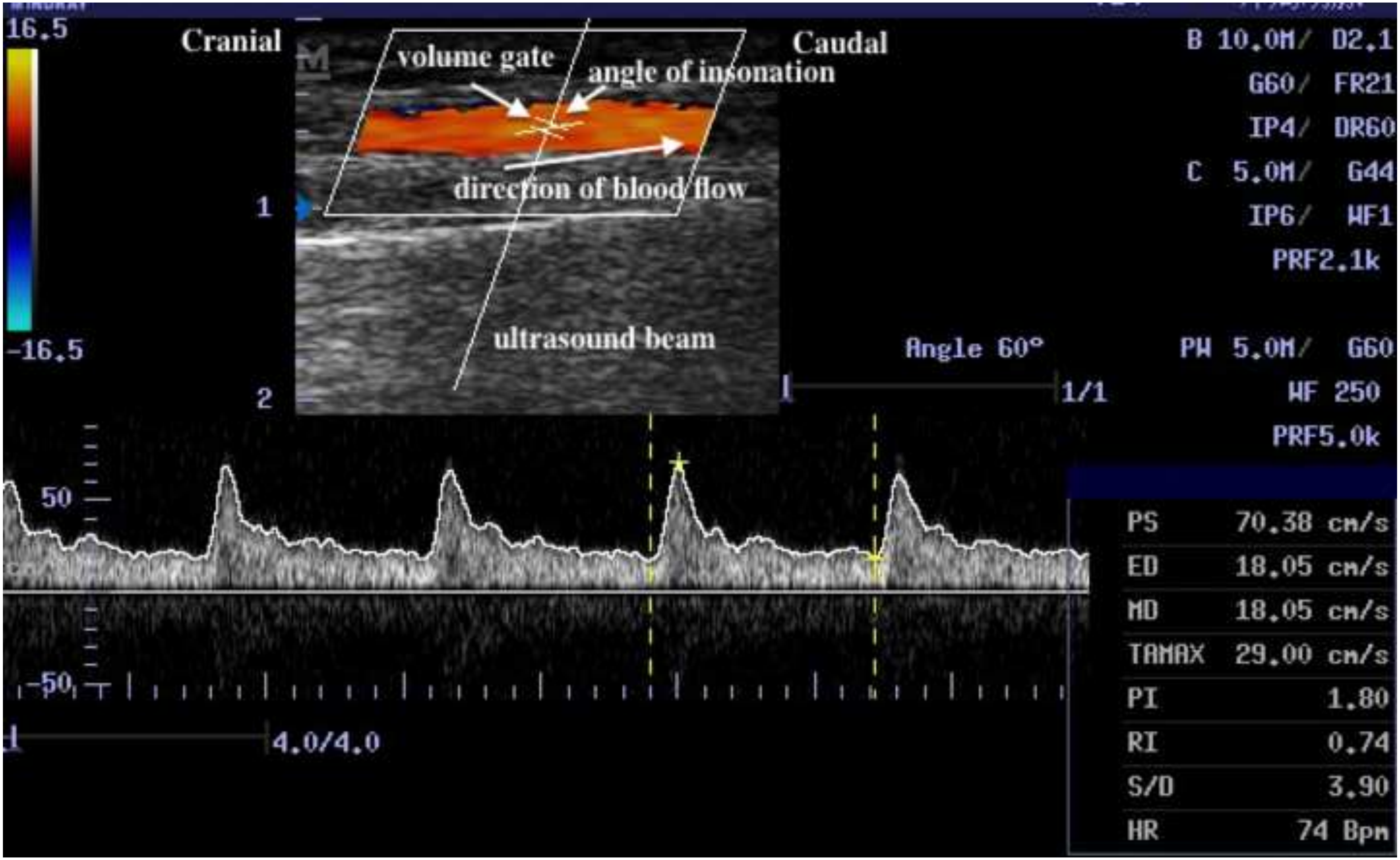

Figure 3
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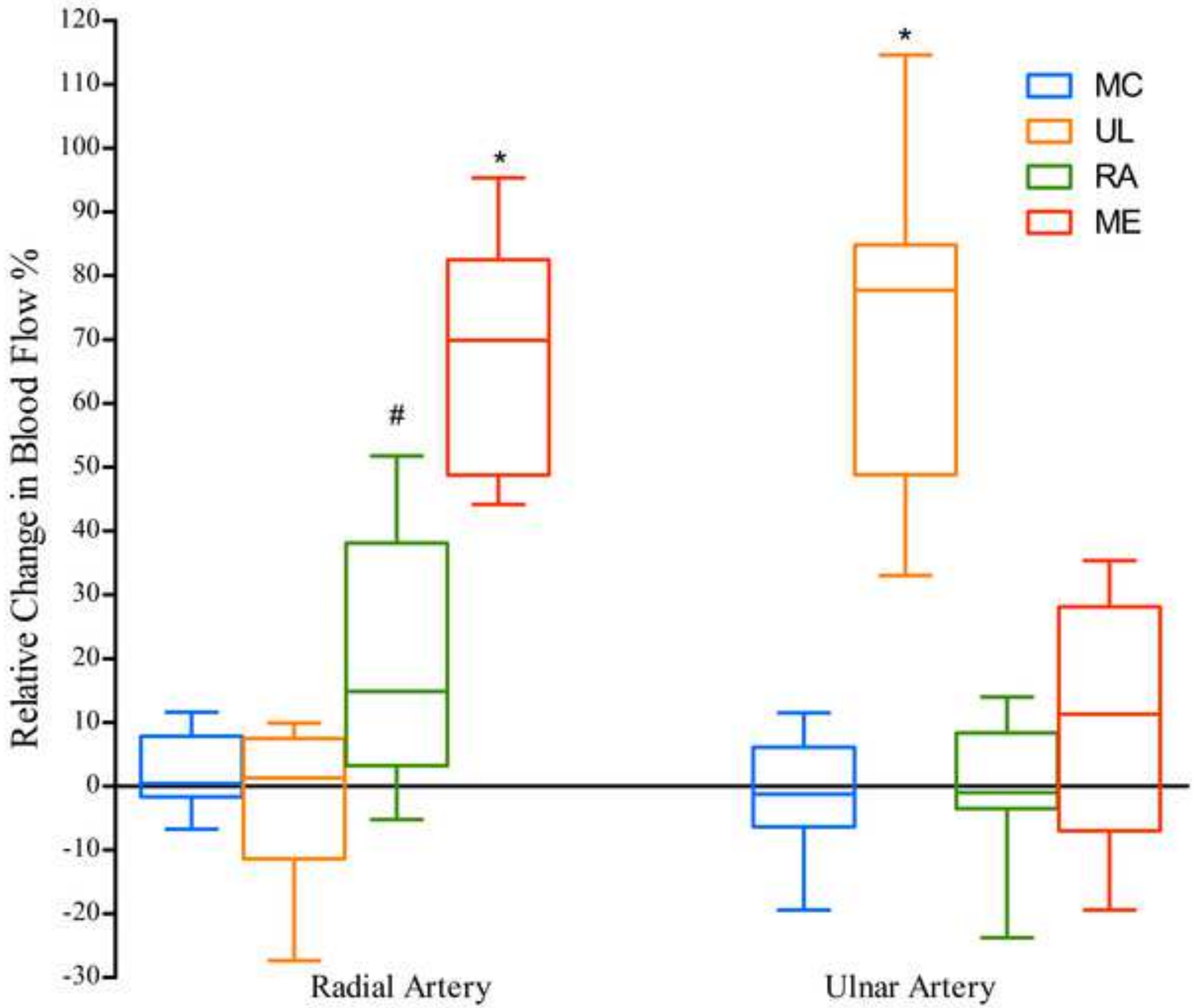

table 1

Table 1 Patients characteristics and changes of MAP and HR in four groups. Values are number or mean (SD)

		Group MC(n=8)	Group UL*(n=7)	Group RA(n=8)	Group ME*(n=7)
Male/female		5/3	4/3	4/4	5/2
Age (yr)		41(12)	31(7)	42(19)	38(17)
Height (cm)		168(8)	167(6)	164(6)	166(9)
Weight (kg)		65(6)	63(7)	57(10)	60(9)
MAP (mmHg)	t_0	88(13)	84(10)	86(13)	88(8)
	t_1	89(14)	80(7)	85(15)	87(7)
	t_2	89(15)	81(8)	85(13)	89(9)
HR (bpm)	t_0	66(7)	72(8)	69(9)	70(10)
	t_1	66(7)	72(8)	69(7)	69(6)
	t_2	68(6)	73(10)	69(9)	70(6)

* 1 patient excluded due to specific nerve blockade failure

table 2

Table 2 Haemodynamic parameters of radial artery in four groups after specific nerve blockade and brachial plexus blockade. Values are mean (SD)

		Group MC(n=8)	Group UL(n=7)	Group RA(n=8)	Group ME(n=7)
PSV	t_0	40.9(12.2)	39.6(7.6)	47.6(18.6)	42.6(10.9)
(cm sec.$^{-1}$)	t_1	40.7(13.1)	40.9(9.4)	50.5(21.5)	52.4(9.8) *
	t_2	58.0(7.2)$^{**\ \#\#}$	60.1(16.2)$^{**\ \#\#}$	69.6(13.6)$^{**\#\#}$	58.5(6.6) $^{**\ \#}$
EDV	t_0	3.4(4.3)	5.8(3.3)	6.0(2.1)	5.5(5.3)
(cm sec.$^{-1}$)	t_1	3.6(4.1)	5.7(3.3)	9.3(5.1)	16.1(5.3) **
	t_2	19.4(3.7) $^{**\ \#\#}$	20.4(6.1) $^{**\ \#\#}$	21.1(8.0)$^{**\#\#}$	18.0(4.1)**
TAMAX (cm sec.$^{-1}$)	t_0	10.2(6.6)	11.4(4.2)	13.1(4.8)	11.5(7.0)
	t_1	10.4(6.2)	11.2(4.6)	18.4(7.8)*	24.8(9.4)**
	t_2	32.0(7.1) $^{**\ \#\#}$	31.0(9.2) $^{**\ \#\#}$	33.3(9.7)$^{**\#\#}$	29.7(5.5)$^{**\ \#}$
CSA(cm^2)	t_0	0.051(0.008)	0.051(0.009)	0.040(0.015)	0.051(0.012)
	t_1	0.053(0.005)	0.053(0.005)	0.044(0.018)	0.069(0.013) **
	t_2	0.073(0.014) $^{**\ \#\#}$	0.074(0.014) $^{**\ \#\#}$	0.061(0.014) $^{**\ \#\#}$	0.073(0.014) **
BF	t_0	31.6(20.1)	29.5(16.1)	33.6(21.9)	35.3(23.1)
(ml min^{-1})	t_1	32.8(19.0)	29.9(16.3)	53.4(42.3)*	100.7(40.7)**
	t_2	141.2(50.7) $^{**\ \#\#}$	118.9(54.7) $^{**\ \#\#}$	125.3(49.6)$^{**\ \#\#}$	130.0(35.7)$^{**\ \#}$

There was no significant difference in each haemodynamic parameter at t_0 among four groups. t_0 is measurement at baseline, before blockade; t_1 is measurement after 30min after SNB; t_2 is measurement at 30min after whole BPB. * P<0.05, ** P<0.01 compared with t_0; $^{\#}$ P<0.05 $^{\#\#}$ P<0.05 compared with t_1.

table 3

Table 3 Haemodynamic parameters of ulnar artery in four groups after specific nerve blockade and brachial plexus blockade. Values are mean (SD)

		Group MC(n=8)	Group UL(n=7)	Group RA(n=8)	Group ME(n=7)
PSV	t_0	42.5(12.9)	45.8(12.5)	51.1(14.6)	43.9(13.5)
(cm sec.$^{-1}$)	t_1	40.2(11.6)	60.5(13.2)*	53.9(15.8)	45.1(11.6)
	t_2	56.9(9.8)** ##	68.7(17.4)* #	68.4(12.2)* #	62.8(11.1)** ##
EDV	t_0	5.9(3.3)	7.9(5.0)	6.0(2.6)	5.3(4.5)
(cm sec.$^{-1}$)	t_1	5.1(2.9）	21.6(9.3)**	6.2(3.0)	7.4(6.9)
	t_2	19.6(7.9） ** ##	26.9(9.7)** ##	18.8(7.4)** ##	20.2(9.5)** ##
TAMAX	t_0	11.2(6.0）	14.9(7.3)	14.0(4.8)	11.1(6.5)
(cm sec.$^{-1}$)	t_1	10.9(4.8）	29.9(12.1)*	14.0(5.2)	11.9(6.9)
	t_2	27.8(8.0)** ##	36.8(14.2)** #	30.5(9.0)** ##	29.0(9.8)** ##
CSA(cm^2)	t_0	0.039(0.019)	0.039(0.011)	0.043(0.014)	0.050(0.013)
	t_1	0.039(0.018)	0.059(0.016)**	0.044(0.011)	0.056(0.014)
	t_2	0.061(0.022)** ##	0.061(0.015)**	0.068(0.013)** ##	0.069(0.018)** #
BF	t_0	28.7(25.6)	35.4(23.0)	37.9(21.6)	34.0(24.7)
(ml min.$^{-1}$)	t_1	27.9(22.2)	111.1(70.1)**	37.7(18.1)	43.8(37.3)
	t_2	104.7(52.8)** ##	144.8(81.5)**##	126.0(47.6)** ##	121.2(58.1)** ##

There was no significant difference in each haemodynamic parameter at t_0 among four groups. t_0 is measurement at baseline, before blockade; t_1 is measurement after 30min after SNB; t_2 is measurement at 30min after whole BPB. * $P<0.05$, ** $P<0.01$ compared with t_0; # $P<0.05$ ## $P<0.05$ compared with t_1.

table 4

Table 4 Skin temperatures(T_S, ℃) of cutaneous innervation areas of specific nerve in four groups after specific nerve blockade and brachial plexus blockade. Values are mean (SD).

		Group MC(n=8)	Group UL(n=7)	Group RA(n=8)	Group ME(n=7)
	t_0	30.0(0.8)	29.8(0.8)	30.2(0.9)	30.0(0.7)
T_S MC	t_1	29.9(0.8)	30.0(0.9)	30.1(1.0)	30.4(0.6)
	t_2	31.3(0.6)$^{**\#\#}$	31.1(0.9)$^{**\#\#}$	33.4(1.0)$^{**\#\#}$	33.7(0.9)$^{**\#\#}$
	t_0	29.1(1.3)	30.1(0.8)	29.5(1.1)	29.7(0.9)
T_S UL	t_1	29.0(1.2)	32.4(0.6)**	29.6(1.1)	29.8(1.0)
	t_2	31.9(1.3)$^{**\#\#}$	32.6(0.6)**	32.6(1.3)$^{**\#\#}$	32.9(0.6)$^{**\#\#}$
	t_0	30.5(1.3)	30.5(1.6)	29.5(1.5)	30.1(0.7)
T_S RA	t_1	30.5(1.3)	30.5(1.3)	29.7(1.6)	32.7(1.0)**
	t_2	32.6(1.0)$^{**\#\#}$	33.2(1.1)$^{**\#\#}$	32.2(1.1)$^{**\#\#}$	33.9(1.0)$^{**\#\#}$
	t_0	28.9(1.7)	30.0(1.3)	29.5(1.6)	29.8(0.9)
T_S ME	t_1	29.0(1.7)	30.1(1.3)	29.5(1.4)	33.3(0.8)**
	t_2	32.4(1.4)$^{**\#\#}$	32.7(1.2)$^{**\#\#}$	32.0(1.3)$^{**\#\#}$	33.7(0.7)$^{**\#}$

There was no significant difference in each skin temperatures at t_0 among four groups. t_0 is measurement at baseline, before blockade; t_1 is measurement after 30min after SNB; t_2 is measurement at 30min after whole BPB. * $P<0.05$, ** $P<0.01$ compared with t_0; $^{\#}$ $P<0.05$ $^{\#\#}$ $P<0.05$ compared with t_1