Pulse wave doppler changes after axillary block using different local anesthetic volumes

Regional hemodynamic changes in axillary block using different local anesthetic volumes

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Abstract

Aim: Brachial plexus block is an anesthetic technique commonly used in upper extremity surgical procedures. Both blood flow increase and vasodilatation occur in ipsilateral upper extremity because of brachial plexus blocks (BPB). There are no enough data related with ipsilateral arterial diameter-blood flow changes in different local anesthetic volumes. Material and Method: Thirty healthy volunteer adult patients who were scheduled for elective hand surgery had an ultrasound-guided axillary BPB (ABPB) for anesthesia. Baseline regional hemodynamic parameters were measured in ipsilateral axillary artery using PWD US. Patients were divided into 3 groups as group 20, 30 and 40 according to using local anesthetic volumes. Diameter, flow velocity measurements were performed with PWD in artery before block (pre-block), 10^{th} minute after block (post-block^{10}) and 60^{th} minute after block (post-block^{60}). Results: The earliest change after the BPB in all groups was a change to a monophasic from triphasic morphology in the PWD spectral waveform for axillary artery. In axillary measurements, There was significant increase PSV, EDV, Vmean between pre-block and post-block10 in group 30 and 40 ($p<0.05$) and there was also significant decrease PSV, EDV, Vmean, TAMV between post-block^{10} and post-block^{60} in group 30 and 40 ($p<0.05$). Discussion: To our knowledge, this is the first report that demonstrates the earliest regional hemodynamic change after ABPB in different volumes. In the groups that were given the volumes above 20 ml arterial restrictive narrowing was evident. The findings of this study support the use of ABPB with low volume local anesthetics aiming to minimize probable pathologic hemodynamic changes.

Keywords

PWD; Axillary Block; Different Volume; Regional Hemodynamic Changes

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Introduction

Brachial plexus block is an anesthetic technique commonly used in upper extremity surgical procedures and axillary brachial plexus block (ABPB) is one of the most commonly used techniques for regional anesthesia of the upper extremity [1]. It is performed by blocking the terminal branches of the brachial plexus including the musculocutaneous, ulnar, medial and radial nerves. High volume local anesthetics were important for block success in past when ultrasound guided block and nerve stimulators could not be applied [2]. To increase the success rate of block, volume up to 80 mL has been reported [3]. Nerve stimulator- and ultrasound-guided low-volume blocks become common to avoid systemic toxicity [4-9]. Both blood flow increase and vasodilatation occur in ipsilateral upper extremity because of brachial plexus blocks (BPB) [10-14]. There are no enough data related with ipsilateral arterial diameter-blood flow changes in different local anesthetic volumes. The purpose of this study was to extensively evaluate relationship between different local anesthetic volume and the regional diameter-flow in the axillary artery after ultrasound guided axillary BPB using pulsed-wave Doppler (PWD) ultrasonography (US).

Material and Method

Patient

After approval of Adnan Menderes University Ethics Committee (Decision 2017/1197) and getting written informed consent, 30 volunteer adult patients who were younger than 70 years, with American Society of Anesthesiologist physical status I to II, and scheduled to undergo elective forearm or hand surgery unrelated to trauma and under a BPB, were prospectively enrolled. Exclusion criteria of the study were pregnancy, history of allergy to local anesthetic drugs, connective tissue disorder, preexisting neurologic or muscular disease, skin infection over the axilla, bleeding tendency or evidence of coagulopathy, presence of an arteriole-venous fistula in the arm, a history of psychiatric illness, uncontrolled hypertension, cardiac disease, diabetes mellitus, autonomic neuropathy, or vascular disease.

No patient was premedicated. ECG electrodes from the ultrasound device were applied to synchronize the PWD spectral waveform to the cardiac cycle for gated measurements.

Measurements of Baseline Diameter, Flow and Velocity

All US scans and PWD measurements were performed by a single investigator. Room temperature was set to 21-24°C with relative humidity 40-60%. Baseline regional hemodynamic parameters were measured in ipsilateral axillary and brachial arteries using PWD US. The axillary artery was detected in intersecting point throughout anterior axillary line by US. Diameter, flow velocity measurements were performed with PWD in both arteries before block (pre-block), 10 minutes after block (post-block^{10}) and 60 minutes after block (post-block^{60}).

Pulsed-wave Doppler US scan was performed using an Esaote Europe B.V. (Philipsweg 1 6227 AJ Maastricht The Netherlands) and a L9-3 linear array transducer (frequency 9-3 MHz). A sagittal scan of the axillary artery was performed, and the B mode US image was optimized. Pulsed-wave Doppler US mode was then activated, the volume gate was positioned in the center of the arterial lumen, and the size of the gate was adjusted to include the entire lumen of axillary artery. Next, the angle of insonation (defined as the angle between the US beam and the direction of blood flow) was adjusted and maintained at 60 degrees or less throughout the measurement (Figure 1).

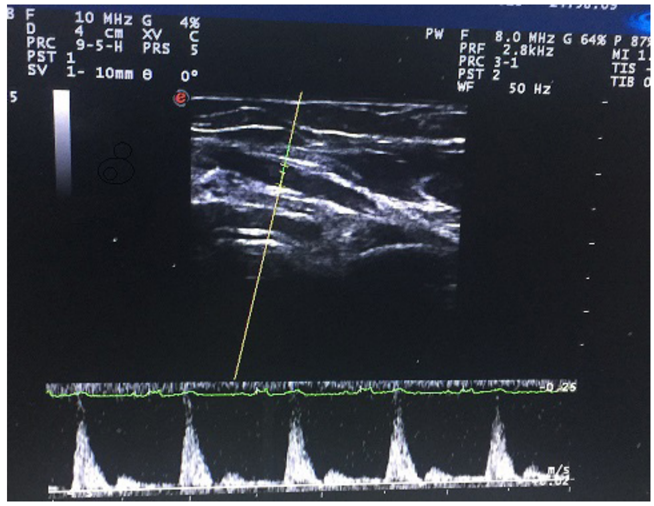

Figure 1. Flow and diameter of axillary artery by Pulse-Wave Doppler US.

The PWD spectral waveform tracing was then activated, and the intelligent Doppler optimization function (iScan) in the US machine was used to optimize the displayed spectral waveform and avoid aliasing. Once an optimal PWD spectral waveform was achieved, it was automatically traced, and the enveloped package of arterial hemodynamic parameters was displayed and recorded. The parameters included peak systolic velocity (PSV, cm/s), end diastolic velocity (EDV, cm/s), mean velocity (Vmean, cm/s), time averaged mean velocity (TAVM, cm/s), ratio of PSV and EDV (S/D), resistance index (RI), and pulsatility index (PI). The displayed values were from an average of 5 consecutive cardiac cycles. The position of the US transducer was then marked on the skin with a skin marking pen, so that the transducer could be returned to the same position for subsequent PWD US and diameter measurements (Figure 1).

Measurement of Axillary Artery Diameter and Calculation of Axillary Artery Blood Flow

The diameter of axillary artery was measured as the vertical distance between the two inner walls of the artery using the electronic caliper in the US machine. The segment of the artery, where the diameter measurement was performed, was located as follows. The B-mode US image was frozen, and the trackball in the US machine was used to scroll through the stored US images to locate the frame that corresponded to the end of diastole of the cardiac cycle that correlates with the onset of the QRS complex on the EKG tracing.

Axillary BPB

The axillary BPB was performed using US guidance and a multiple injection technique previously described (16). Patients who signed the voluntary consent form were divided into 3 groups using the random number table. ABPB of the groups was administered at the following doses:

Group 20: In totally 20 ml volume, 15 mL of 0.5% bupivacaine and 5ml of %2 lidocaine without epinephrine were used for the ABPB.

Group 30: In totally 30 ml volume, 15 mL of 0.5% bupivacaine, 5ml of %2 lidocaine and 10 ml of saline without epinephrine were used for the ABPB.
Group 40: In totally 40 ml volume, 15 mL of 0.5% bupivacaine, 5ml of %2 lidocaine and 20 ml of saline without epinephrine were used for the ABPB.
Ultrasound measurements were obtained via PWD before blockage and 10 and 60 minutes after from the end of the local anesthetic injection.

Outcome Data Recorded After the ABPB

Regional hemodynamic parameters and the diameter of the axillary artery were measured in the ipsilateral axillary artery, as described previously, and repeated at 10th and 60th minute after the ABPB.

Statistical Analysis

Normality of the data recorded was tested using the Kolmogorov-Smirnov test. Because the data were normally distributed, they were presented as mean±SD unless otherwise stated. For each parameter, every measurement after the ABPB was compared with the baseline value using the contrasts in repeated-measures analysis of variance and for each group time dependent changes were compared Friedman's test. A p value smaller than 0.05 was considered as statistically significant. SPSS for Windows 15.0 (SPSS, Inc, Chicago, Ill) was used for statistical analysis.

Results

The axillary BPB and examination by PWD US of axillary artery were successfully performed in all of the patients. There were totally 28 men and 2 woman with a mean (SD) age of 41 (16) years, weight of 72 (2.3) kg, height of 165 (4) cm, and a body mass index 26.2 (1.8) kg/m^2. In all patients, there were complete motor and sensory block. None of the patients had to additional anesthetic and analgesic. No complications were related with technical or local anesthetic injections by BPB. The earliest change after the BPB in all groups was a change to a monophasic from triphasic morphology in the PWD spectral waveform due to disappearance of the negative flow during early diastole and an elevation in the diastolic flow for axillary artery (Figure 2). The changes of each parameter compared post-block[10] and post-block[60] according to pre-block for axillary artery of all groups are shown in Table 1.

Axillary Measurements (Table 1)

There was significant increase PSV, EDV, Vmean between pre-block and post-block[10] in group 30 and 40 (p<0.05). There was also significant decrease PSV, EDV, Vmean, TAMV between post-block and post-block[60] in group 30 and 40 (p<0.05). S/D value significantly decreased both between pre-block with post-block[10] and post-block[10] with post-block[60] in group 30 and 40. Whereas in group 20, the increase and decrease for PSV, EDV, Vmean, TAMV were not significant (p>0.05). There was significance between pre-block and post-block[60] for RI, PI, FVI group 30 and 40 (p<0.05), whereas there was significant narrowing between pre-block and post-block[10] for diameter in group 30 and 40 (p<0.05), was significant dilatation between post-block[10] and post-block[60] in group 30 and 40 (p<0.05). There was no significance between these measurements in group 20. While the increase in BF between both pre-block with post-block[10] and pre-block with post-block[60] were significant for group 30 and 40 (p<0.05), while not significant for group 20 (p>0.05).

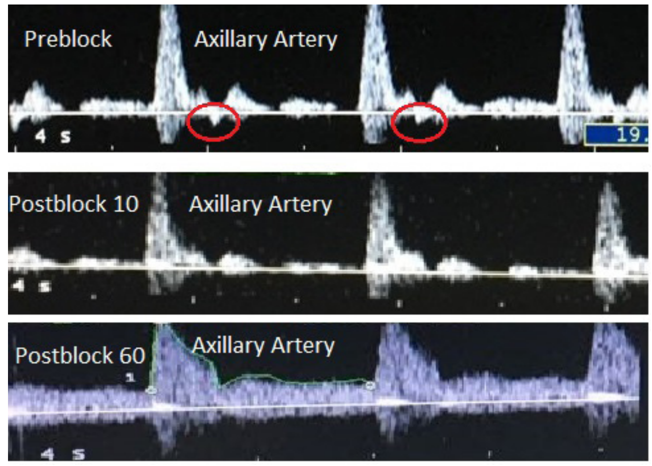

Figure 2. Flow curve of axillary artery in pre-block, post-block10 and post-block60
Red Rings: Triphasic waveform

Discussion

In this study, we used PWD US to quantify the changes in regional Doppler in the ipsilateral axillary artery pre-block, post-block[10] and post-block[60] in axillary BPB.
This study showed that 30 and 40 ml volumes ipsilateral increased PSV, EDV, and Vmean in axillary artery and diminished diameter in axillary artery after ABPB, but 20 ml volume did not significantly change these measurements.
However, there are many reports partially evaluated only the regional hemodynamic changes. To our knowledge, our study is the first report that evaluates comprehensively the regional hemodynamic changes after applied different volumes BPB. In this study, we recorded regional hemodynamic parameters pre-block post-block[10] and post-block[60]. The study was designed in these periods because of practical reasons and to avoid delays in a busy operating room schedule. Therefore, our results may not represent the peak change in regional hemodynamic parameters after the BPB. Following steps were taken to minimize measurement errors during this study. They included; having all US scans and PWD measurements performed by a single investigator, marking the first measured location both the axillary artery, making sequence measurements from the same location, returning the US transducer to the same position over axillary artery for every measurement, controlling the ambient temperature and humidity of the anesthetic procedure room, avoiding undue pressure on axillary and brachial arteries with the transducer during the PWD measurements, maintaining the angle of insonation at 60 degrees or less.
As Li et al. show, the earliest change after the BPB is a change in the PWD spectral waveform from a triphasic to a monophasic waveform, with disappearance of the reversed flow during early diastole and an elevation in the diastolic flow [15]. Triphasic pattern defined as prodiastolic flow that is a short reversal of flow during early diastole, after systole [16-18]. It is related with high peripheral vascular resistance (PVR). Iskender et al.

Table 1. Axillary artery meaasurements by PWD-US.

Parameter	Group	Pre-block⁰	Post-block¹⁰	Post-block⁶⁰	Interactions	pvalue
PSV cm/s	20	44.00 ± 51.37	47.51 ± 155.65	48.32 ± 64.60	Group	0,648
	30	62.56 ± 70.63	76.67 ± 43.71	69.82 ± 72.21	Time	0,001
	40	66.35 ± 47.82	117.00 ± 114.94	97.46 ± 51.89	Groupby time	0,391
EDV cm/s	20	7.97 ± 17.52	8.11 ± 13.13	7.43 ± 5.86	Group	0,129
	30	12.14 ± 17.95	24.98 ± 14.00	13.70 ± 17.13	Time	0,163
	40	12.25 ± 10.03	36.72 ± 38.33	25.06 ± 19.35	Groupby time	0,762
Vmean cm/s	20	7.33 ± 3.16	8.76 ± 4.17	8.06 ± 1.91	Group	0,006
	30	6.75 ± 3.44	19.61 ± 5.98	13.96 ± 10.91	Time	0,000
	40	9.44 ± 5.60	34.63 ± 37.49	25.54 ± 13.74	Groupby time	0,008
TAMV cm/s	20	10.31 ± 6.79	15.04 ± 16.47	10.38 ± 6.37	Group	0,109
	30	10.25 ± 9.13	13.38 ± 8.35	17.76 ± 13.51	Time	0,000
	40	12.34 ± 8.04	30.79 ± 31.92	24.43 ± 14.15	Groupby time	0,003
RI	20	1.02 ± 0.07	0.97 ± 0.09	0.94 ± 0.05	Group	0,002
	30	1.04 ± 0.13	0.88 ± 0.12	0.87 ± 0.11	Time	0,000
	40	0.89 ± 0.09	0.76 ± 0.11	0.78 ± 0.12	Groupby time	0,302
PI	20	4.28 ± 0.98	3.87 ± 0.85	4.01 ±0.54	Group	0,000
	30	5.51 ± 2.44	2.98 ± 1.44	2.91 ± 1.05	Time	0,012
	40	2.69 ± 0.79	1.97 ± 0.98	1,87 ± 0.85	Groupby time	0,124
S/D	20	29.23 ± 25.02	22.24 ± 20.10	18.50 ± 8.47	Group	0,156
	30	23.29 ±31.30	15.85 ± 18.74	10.25 ±8.25	Time	0,128
	40	11.41 ± 10.22	12.36 ± 24.64	6.01 ± 4.84	Groupby time	0,962
FVI	20	5.18 ± 2.12	6.78 ± 1.38	7.35 ± 2.28	Group	0,039
	30	4.70 ± 1.92	6.87 ± 1.65	9.13 ± 2.78	Time	0,000
	40	5.17 ± 1.75	10.33 ± 7.65	13.63 ± 5.21	Groupby time	0,025
Diameter, cm	20	0.42 ± 0.20	0.40 ± 0.06	0.43 ± 0.17	Group	0,579
	30	0.48 ± 0.12	0.37 ± 0.05	0.44 ± 0.05	Time	0,000
	40	0.45 ± 0.06	0.27 ± 0.04	0.39 ± 0.03	Groupby time	0,286
BF ml/min	20	66.21 ± 26.45	62.60 ± 46.57	69.08 ± 38.24	Group	0,312
	30	78.40 ± 77.41	204.20 ±432.50	131.43±107.30	Time	0,040
	40	120.01±95.04	171.95 ± 116.49	194.82±115.64	Groupby time	0,478

*p<0.05.

show that inversion of the diastolic curve and disappearance of the protodiastolic flow in the PWD spectral waveform after an interscalene BPB [12]. Li et al emphasize that it may be clinically useful as an objective indicator of the onset of a BPB in patients who are sedated, unconscious, or unable to provide a reliable response to sensory motor assessment [15]. Our work also supported the disappearance of the triphasic waveform after BPB such as Iskender [12] and Li's [15] studies. Li et al found an increase in the diameter of the ipsilateral brachial artery and blood flow velocity (PSV, EDV, Vmean, and TAVM) and a decrease in S/D ratio, RI, and PI in the ipsilateral brachial artery after the axillary BPB [15]. We found similar results for axillary artery by PWD in group 30 and 40, but our group 20 did not support Li's results .We believe this may be due to axilla, the constricted area, and the sympathetic blockage will the blood flow will increase and decrease the PVR with distal vasodilatation. We found reduction of PI and RI in axillary measurements, in all group. Group 20 had no significant diameter change. Group 30 and 40 had significantly narrowed diameter of axillary artery at 10th minute compared to pre-block.

However, it significantly expanded and returned to pre-block's diameter, at 60th minute. These results showed that, the more the local anesthetic volume for BPB increases, the more the regional hemodynamic changes are. Current literature is limited to measurements from a single artery. [13, 14-19]. Further studies, assessing measurements from multiple arterial levels of ipsilateral extremity should be held, to investigate the regional hemodynamic changes after ABPB.

To our knowledge, this is the first report that demonstrates the earliest regional hemodynamic changes after ABPB using varying volumes of local anesthetics. In addition, the most important and the first finding was the loss of the triphasic waveform in axillary artery after the ABPB. Our study also showed that the most significant changes were observed when high local anesthetic volumes were used for ABPB. In the groups that were given the volumes above 20 ml arterial restrictive narrowing was evident. The most appropriate volume causing minimal hemodynamic changes was observed to be 20 ml for ABPB. The findings of this study support the use of ABPB with low volume local anesthetics aiming to minimize probable pathologic hemodynamic changes.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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