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Brachial Plexus Blockade in Elbow, Arm or Hand Surgeries

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Abstract: This study was performed to compare the transarterial (T) and paraarterial (P) approaches for brachial plexus block, in terms of success rate, onset time and duration of analgesia and complications. Hundred patients scheduled for elbow, arm or hand surgery at Tabriz Shohada hospital from October 2005 to December 2006, randomly allocated into two groups (n = 50 per group), based on the approach chosen to block the brachial plexus. For local anesthesia each patient received 22.5 mL of 2% lidocaine with 17.5 mL distilled water (in total volume of 40 mL and total dose of 450 mg) and 1/200000 epinephrine with a standard 23 gauge needle. All patients were sedated with 1 μg kg^{-1} of fentanyl and 0.02-0.05 mg kg^{-1} of midazolam. There was no statistical difference between the groups in duration of analgesia but the onset of anesthesia was significantly quicker in paraarterial technique (3.5 vs. 13.4 min, $p<0.001$). Success rate was 86% in group T and 98% in group P ($p = 0.03$). Two percent of patients in group P and 6% in group T had total failure of the block and 8% of the group T required supplementary drug. Paraarterial method for axillary block is preferable due to quicker onset of blockade and higher success rate.

Key words: Brachial plexus, axillary block, paraarterial, transarterial, lidocaine

INTRODUCTION

Brachial plexus block using axillary approach is a simple and safe method of regional anesthesia often used for elbow, forearm and hand surgery (Smigovec *et al*., 2008; Langen *et al*., 2008; Gürkan *et al*., 2008). A variety of anatomic factors have been thought to affect the spread of a solution injected around the brachial plexus, including the presence of a sheath, the head of the humerus and the existence of septae within the plexus (Cornish *et al*., 2007). Different techniques can be used to achieve brachial plexus block (Smigovec *et al*., 2008; Langen *et al*., 2008; Gürkan *et al*., 2008). Many of the traditional approaches have, however, suffered from inconsistency in blocking the musculocutaneous and radial nerves in particular (Coventry *et al*., 2001). A variety of agents and volumes of local anaesthetic, as well as different methods for injection have been described in an attempt to improve efficacy (Liguori *et al*., 2006; Smigovec *et al*., 2008; Langen *et al*., 2008; Gürkan *et al*., 2008). The choice usually depends on personal preference based on the perceived efficacy of block in the surgical field and specific adverse effects in individual patients (Coventry *et al*., 2001). The axillary approach avoids the more significant adverse effects of the more proximal approaches but has inconsistency in achieving complete blockade (Coventry *et al*., 2001). Surgical procedures to the distal humerus, elbow and proximal forearm are ideally suited to regional anesthetic techniques. Selection of the preferred approach is determined by the innervation of the surgical site, the risks of regional anesthesia-related complications and the preference and experience of the anesthesiologist. The axillary approach to the brachial plexus is the most commonly used because of its ease of performance, patient acceptance, safety and reliability, particularly for hand and forearm surgery (Turkan *et al*., 2002).

Today, there is a tendency for regional blocks in order to avoid the complications of general anesthesia. There are several techniques for the Brachial plexus block with axillary approach, including transarterial (T) and paraarterial (P) approaches. The aim of the present study was to compare the two approaches in terms of success rate, speed of onset and duration of analgesia and their possible side effects.

MATERIALS AND METHODS

We studied 100 patients scheduled for surgery of the elbow, arm or hand surgery at Tabriz Shohada hospital from October 2005 to December 2006. The patients were = 16 years old and were belonging to ASA (American Society of Anesthesiologists) grade of I to III. The local ethics committee approved the study and all

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participants gave informed written consent. Patients refusing a local anesthetics technique were excluded, as were those with dementia, peripheral neuropathy, vasculopathy, coagulopathy, limitation in shoulder motions or sensitivity to amide local anesthetics.

The patients randomly allocated into two groups (n = 50 per group) based on the approach chosen to block the brachial plexus; one group received axillary block through transarterial approach (group T) and the other group received axillary block through paraarterial approach (group P). All patients were sedated with 1 μg kg^{-1} of fentanyl and 0.02-0.05 mg kg^{-1} of midazolam through IV line. Then, for local anesthesia each patient received 22.5 mL of 2% lidocaine with 17.5 mL distilled water (in total volume of 40 mL and total dose of 450 mg) and 1/200000 epinephrine with a standard 23 gauge needle. The anesthetic agent was injected by 23 G scalp vein and 50 mL syringe, when the patient was in the supine position with the head facing away from the side to be blocked. As mentioned above the dosage of lidocaine was calculated as 6.5 mg kg^{-1} which injected with epinephrine. This was because of slow distribution and absorption of the drug from axillary region and the region was considered as an isolated cite. The selection of drug type was performed according to the duration of surgery which was less than 2 h in average. The arm on the side of the block placement was abducted 90° and formed a roughly 90° angle in the elbow joint with the forearm on a 10 cm height pillow. After a thorough skin preparation, the pulse of the axillary artery is palpated high in the axilla (Nishikawa *et al*., 2000; Sites *et al*., 2006; Movafegh *et al*., 2006). In transarterial method, a needle is inserted just in front of the palpating fingers and advanced at an angle 90° to the artery. The needle is advanced slowly until the needle passes the artery. Then, two-thirds of the anesthetic drug is injected behind the artery and the remaining one-third is injected anterior to the artery when exit the needle from it with intermittent aspiration to rule out an intravascular injection (Sites *et al*., 2006). In paraarterial method, the patients were asked to inform when parasthesia is initiated in any region of hand. Two separate scalp veins were used. Inducing parasthesia in internal and external part, the separate injections of 20 mL lidocaine was made in both sides of the artery (Sites *et al*., 2006).

In axillary sheath, the median and musculocutaneous nerves lie laterally to centrally located axillary artery, with ulnar and radial nerves medially to it. In paraarterial method we inserted the scalp vein lateral to axillary artery for achieving the median nerve paresthesia. Then the second scalp vein is inserted medially to the artery for achieving the ulnar or radial nerve paresthesia. The resulted paresthesia in each insertion is expressed by patient and then the exact cite for injection of anesthetic drug is determined. This can be performed by nerve stimulator but it is not only painful for patient but also is time consuming. After finding the suitable cite in both sides of the artery, 20 mL of the selected drug is injected (Miller, 2008).

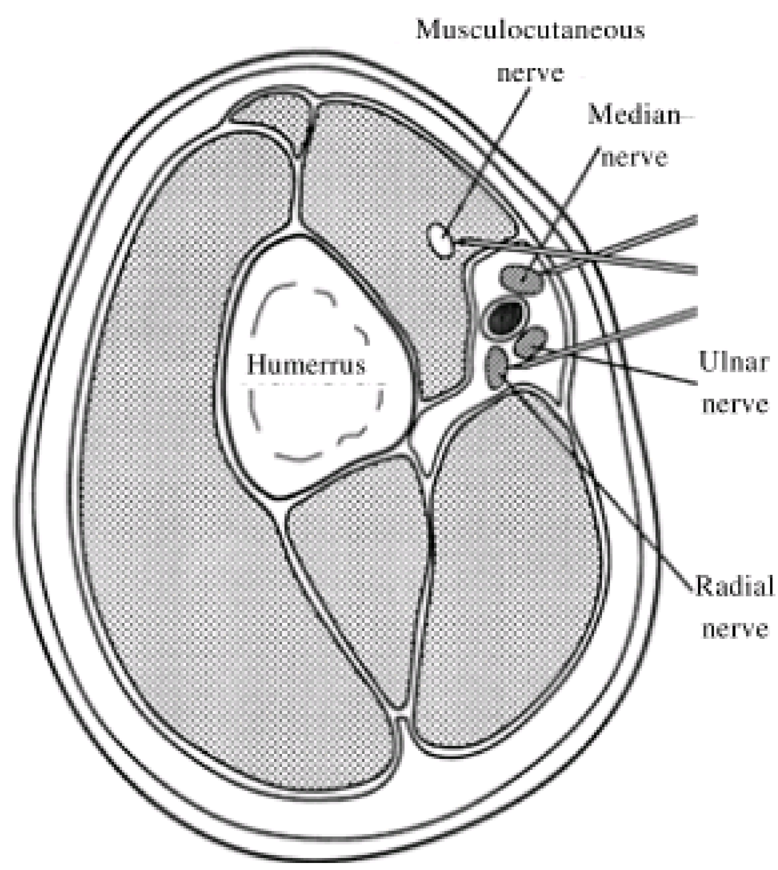

Fig. 1: Transverse section through the proximal humerus showing the relationship of the brachial plexus nerves to the axillary artery (Coventry *et al*., 2001)

Because the probability of not injection within the sheath is also present in transarterial method, the paraarterial method was performed without the nerve stimulator in order to the both method to be similar. Other studies have compared the paraarterial method using paresthesia and nerve stimulator (Miller, 2008).

The musculocutaneous nerve is not consistently blocked with the axillary brachial plexus block, because this nerve leaves the brachial plexus sheath proximally (Fig. 1). Due to the large area covered by this nerve and its importance in achieving complete anesthesia of the forearm and biceps, a block of the musculocutaneous nerve is often necessary for complete anesthesia. This is achieved with a separate injection of 3-5 mL lidocaine 1% by inserting the needle into the coracobrachial muscle in proximal part of the arm.

Variables including age, sex, heart rate, Systolic Blood Pressure (SBP) and Siastolic Blood Pressure (DBP), initiation time of complete analgesia, duration of analgesia, site of operation, initiation time of radial median and ulnar nerves analgesia, musculocutaneous analgesia and duration of their analgesia, possible complications including hematoma formation, infection and also ASA grade were collected by one of coworkers who did not informed about the type of approach. The same person analyzed the data by SPSS statistical software. The qualitative and quantitative variables in two groups were assessed using Chi square test and Independent t-test, respectively.

RESULTS

Of 100 studied patients 77 (77%) were male and 23 (23%) were female, with age range of 16-76 years and mean age of 33.2±17.1 years. The patients had the mean height and weight of 168.3±8.3 cm (range: 155-190 cm) and 69.2±13.4 kg (range: 45-110 kg). Pulse rate, SBP and DBP were recorded as 73.3±7.1 bpm, 121.2±9.6 mmHg and 70.5±10.3 mmHg, respectively. ASA grade of patients was I in 85%, II in 14% and III in 1% of patients. Associated conditions including diabetes, hypertension, obesity, addiction, COPD, asthma and Alzheimer were seen only in 9%. The most common site of operation was forearm (50%) and the other sites were elbow, fingers, hand and wrist. Four patients required additional drugs and four received general anesthesia. The mean times of operation, analgesia and obtaining total blockade were 105±34.3, 214.9±40.6 and 8.5±6.1 min, respectively. Table 1 shows the demographic data in both groups.

Table 1: Comparison of demographic data in two groups

Parameters	Groups	Mean value	Range	p-value
Age	T	37.40±17.3	16-76	0.013
	P	29.00±15.9	16-73	
Height	T	167.0±8.8	155-190	0.13
	P	169.6±7.7	156-185	
Weight	T	71.70±15	45-110	0.06
	P	66.70±11.2	47-92	

Table 2: Comparison of findings of patients in two groups

Results	Group T	Group P	p-value
ASA grade I	80%	90%	>0.05
ASA grade II	18%	10%	
ASA grade III	2%	0%	
Site of operation			
Elbow	24%	12%	0.63
Forearm	34%	68%	
Wrist	13%	4%	
Hand	11%	12%	
Fingers	18%	4%	
SBP (mm Hg)	124.1±11	118.3±7.1	0.002
DBP (mm Hg)	71.4±12.9	69.6±7	0.379
Heart rate	75.1±8.1	71.5±5.4	0.014
Duration of surgery (min)	107.5±36.9	103.4±32.2	0.58
Onset time of anesthesia (min)	13.38±4.63	3.48±2.16	<0.001
Duration of anesthesia (min)	221.1±51.3	208.8±25.3	0.13
Musculocutaneous n. blockade	92%	100%	0.06
Coracobrachialis n. blockade	100%	100%	1.00
Radial n. blockade	94%	98%	0.31
Median and Ulnar n. blockade	100%	98%	0.5
Need for additional IV drug	8%	0%	0.059
Need for general anesthesia	6%	2%	>0.05
Complete blockade	86%	98%	0.03

Ninety percent of patients in group P and 64% of patients in group T were male (p = 0.002). About arterial O_2 saturation, there was no problem in each group. Other findings of patients in two groups are compared in Table 2.

All of four patients requiring additional IV drugs and 3 of four patients requiring general anesthesia were male. Also, 77% of all patients receiving complete block were male. The relation between sex and block results was not statistically significant (p = 0.54). There was not any side effect in each group.

All of four patients requiring additional IV drugs and 3 of four patients requiring general anesthesia were belong to ASA grade I; also, 85% of patients obtaining analgesia were belong to this grade.

Of four patients requiring additional IV drugs, two had forearm surgery, one had elbow surgery and one had wrist surgery (p>0.05). Also, of four patients requiring general anesthesia, two had elbow surgery, one had forearm surgery and another had finger surgery (p>0.05).

DISCUSSION

The majority of upper extremity surgeries are performed on an ambulatory basis under intravenous regional anesthesia or brachial plexus blockade. The former technique is easy to perform, has a rapid onset and a high success rate but provides limited post-operative analgesia. Brachial plexus blockade provides excellent intra-operative anesthesia as well as post-operative analgesia, eliminates the need for post-operative opioids, resulting in a decrease in recovery time, shortened hospital stay, increased patient satisfaction and ultimately a decrease in peri-operative costs when compared with general anesthesia (Brown, 2002).

Schroeder *et al*. (1996) reported the success rates for interscalene, supraclavicular and axillary blocks for 330 surgeries about the elbow in 260 patients. Adequate surgical anesthesia was present in 283 cases, with an overall success rate of 86%. Adequate surgical anesthesia was present in 89% of axillary, 78% of supraclavicular and 75% of interscalene blocks. Successful axillary block was achieved in 95% of blocks using paresthesia technique, 88% of blocks using a nerve stimulator/motor response, 94% of combination blocks and 81% of blocks performed exclusively with transarterial injection. These results demonstrate that the axillary approach to the brachial plexus may be successfully used for surgical procedures about the elbow (Schroeder *et al*., 1996). Because of the ease of application and fewer side effects, axillary block of brachial plexus is the most common used technique in different kinds of surgical procedure on elbow, forearm and hand. This block can be implemented using different methods such as transarterial and paraarterial approaches (Miller, 2008; Brown, 2005; Jacques, 2008; Vincent, 1993). An axillary brachial plexus nerve block by a transarterial approach is commonly used to achieve regional anesthesia for hand surgery (Andersson *et al*., 2006). Porter *et al*. (2005) suggested that spread of injectate posterior to the second part of the axillary artery is associated with successful block (Porter *et al*., 2005). Stan *et al*. (1995) conducted a prospective consecutive study involved 1,000 adult patients scheduled for surgery using transarterial axillary brachial plexus block. This study demonstrated the safety and efficacy of the transarterial technique in achieving brachial plexus block (Stan *et al*., 1995). In this study, success rate and onset of block were significantly more in paraarterial technique. It seems to be due to the direct injection of anesthetic drug over the nerve or close to it. In transarterial method there is not need for paresthesia sensation and the possibility of drug spread in areas that are not containing the nerve is high causing the less complete block in comparison with paraarterial approach. Also, the quicker initiation of block in paraarterial method in comparison with transarterial approach is due to the direct injection of anesthetic drug over the nerve or close to it. Turkan *et al*. (2002) evaluated three techniques of axillary blockade on 69 patients scheduled for surgery on the upper extremity: Group A (n = 23) were treated with the Winnie technique (paresthesia taking); group B (n = 23) underwent transarterial technique; and group C (n = 23) received the combination technique. All three techniques were reliable for axillary blockade. But the onset, complete blockade time and quality of analgesia were better with the combined technique than with the transarterial and Winnie techniques. Coventry *et al*. (2001) compared a single transarterial injection on median nerve (group 1) with double injection divided between median and radial nerves (group 2). All 60 patients received 30 mL of lidocaine 15 mg mL^{-1} with epinephrine 5 μg mL^{-1}. More complete sensory blockade with more rapid onset of blockade occurred in group 2 patients. In this study, for local anesthesia each patient received 22.5 mL of 2% lidocaine diluted in 17.5 mL distilled water and 1/200000 epinephrine. However, we achieved more complete sensory blockade with more rapid onset of blockade occurred in group P (paraarterial group).

The perivascular technique of axillary brachial plexus block results in incomplete block of radial and musculocutaneous nerves in 10-20% of patients. With the transarterial technique and a large dose of mepivacaine, success rates of 99% have been reported (Pere *et al*., 1993). Pearce *et al*. (1996) studied 200 minimally-sedated patients presenting for upper limb surgery to determine the overall clinical success rate, extent of cutaneous neural blockade, reliability and complication rate of each indicator of axillary sheath entry and degree of patient satisfaction. Alkalinized mepivacaine 1.2%, 50 mL was injected. The cutaneous distribution of the block was mapped in the presence of minimal sedation. The overall clinical success rate of paraarterial approach was 92.5%, improving to 99% with supplementary nerve blocks. Complete an aesthesia distal to the elbow was achieved in 85% of patients (Pearce *et al*., 1996). We achieved the complete blockade of 86% in transarterial and 98% in paraarterial method. Perris and Watt (2003) presented their experience of >1000 axillary brachial plexus blocks performed over 13 years. Using a technique that involves the location of individual nerves with a nerve stimulator, the overall success rate was 97.9% with no failures in the last 500 blocks. The authors conclude that technique and experience are the keys to success, but that high success rates can be achieved in a short time if anesthetists are trained by experts in regional anesthesia (Perris and Watt, 2003). These findings were supported by Guay (2005).

Present study suggests that the onset time of analgesia is significantly shorter in paraarterial method in comparison with transarterial approach. Manoudis *et al*. (2004) using ropivacaine in transarterial approach, recorded the onset of sensory and motor blockade time of 15.2 and 20.1 min, respectively (Manoudis *et al*., 2004). March *et al*. (2003) used 40 mL mepivacaine of 1% in paraarterial approach and reported the motor blockade of onset time of 16±8 min. The apparent difference in onset time reported by different studies may be due to different local anesthetics used.

Present experiences showed that paraarterial method has shorter onset time of analgesia and is preferred in busy operation room. But this is true when is perform by expert anesthesiologist, because it requires repeated tries for finding the location of the nerve and these tries may be double when the patients has not cooperation. In some patients, palpation of the axillary artery may be difficult; a common scenario in young, athletic men. Considering these facts, the paraarterial method becomes a time consuming approach. In present study, 8% of patients required additional medication and 8% required general anesthesia. Smigovec *et al*. (2008) assessed 158 patients undergoing upper extremity surgery under brachial plexus block. Successful anesthesia was achieved in 135 (85.0%) patients using brachial plexus block alone, 19 (12.5%) patients required additional medication, two patients required supplementation with intravenous regional anesthesia and another two patients required general anesthesia (Smigovec *et al*., 2008).

We had no side effect in our series, probably because of using tight pressure on artery for 7 min after injection, use of sterile condition and slow and careful injection. Smigovec *et al*. (2008) investigated the incidence of local and systemic complications or allergic skin reactions in brachial plexus block. There were no significant complications attributed to the anesthetic technique (Smigovec *et al*., 2008). In Pearce *et al*. (1996) study, complications were common, but generally mild and transient: mild acute local an aesthetic toxicity, 3.5%; axillary tenderness and bruising, 12%; and dysesthesias, 12.5%. Despite this, patient satisfaction was high (97%) . Andersson *et al*. (2006) designed a retrospective study to evaluate efficacy and safety of transarterial brachial plexus block for acute and elective operations. Anesthetic records of 189 of all 5520 patients (1996-2000) who had axillary brachial plexus blocks for hand surgery were reviewed. Successful axillary block was achieved in 5128/5520 (93%) of patients. Four patients had a toxic drug reaction or axillary haematoma with a transient neurological deficit. Medical complications were recorded in the anesthetic register in less than 0.7% of axillary brachial plexus procedures. Axillary brachial plexus block by a transarterial approach is effective and safe in hand surgery (Andersson *et al*., 2006). In study by Stan *et al*. (1995) two patients presented with a sensory paresthesia (0.2%) in the distribution of the ulnar nerve and the musculocutaneous nerve that most likely occurred during supplementation of an incomplete block. Three patients presented with upper-arm myalgias (0.3%) related to tourniquet injury. After the operation, two patients developed reflex sympathetic dystrophy, which responded to stellate ganglion blocks. Vascular complications, including transient arterial spasm in 10 of 996 (1%), unintentional intravascular injection in 2 of 996 (0.2%) and small (0-2 cm) hematoma formation in 2 of 996 (0.2%), were recognized but did not require any intervention other than close observation (Stan *et al*., 1995).

We sedated all patients with 1 μg kg^{-1} of fentanyl and 0.02-0.05 mg kg^{-1} of midazolam. Then, for local anesthesia each patient received 22.5 mL of 2% lidocaine with 17.5 mL distilled water and 1/200000 epinephrine. Although epinephrine commonly is added to local anesthetics for regional anesthesia, rarely it may cause undesirable hemodynamic side effects (Dogru *et al*., 2003). Low-dose epinephrine (25 vs. 200 μg epinephrine mixed with 35 mL of 1.5% lidocaine) offers more stable hemodynamics and similar blockade and thus may be beneficial for patients undergoing forearm and hand surgery who are at risk for tachycardia and/or hypertension (Dogru *et al*., 2003). Peripheral application of fentanyl to lidocaine for axillary brachial plexus blockade provides an improved success rate of sensory blockade and prolonged duration (Nishikawa *et al*., 2000).

CONCLUSION

In conclusion, paraarterial method for axillary block is preferable due to quicker onset of blockade and higher success rate, better results of complete block and the less need for additional drugs or general anesthesia.

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