Original Article
Ipsilateral vocal cord paralysis after interscalene brachial plexus block for clavicle surgery: anatomical considerations and technical recommendations - a case report

Hyungtae Kim[1], Hwa Young Jang[1], Hyun Joo Heo[2], Young Duck Shin[3], Sang-Hi Park[3], Jung-Hee Choi[3], Hyeon-Tae Kim[3], Hyung-Min Lee[3]

[1]Department of Anesthesiology and Pain Medicine, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea; [2]Department of Anesthesiology and Pain Medicine, Presbyterian Medical Center, Jeonju, Korea; [3]Department of Anesthesiology and Pain Medicine, Chungbuk National University Hospital, College of Medicine, Chungbuk National University, Cheongju 28644, Chungbuk, Korea

Abstract: Interscalene brachial plexus block (IBPB) offers many advantages over general anesthesia for anesthesia and pain management during shoulder, clavicle, and humerus surgery. It also has well-known complications, such as nerve injury, Horner's syndrome, and diaphragmatic paralysis. Hoarseness is a rare complication and most cases are caused by blockage of the recurrent laryngeal nerve (RLN). We experienced a case of ipsilateral vocal cord paralysis that lasted for several months after IBPB for a clavicle surgery. A 37-year-old woman underwent open reduction and internal fixation of the left clavicle under regional anesthesia by IBPB. After surgery, ipsilateral vocal cord paralysis was described to the patient and the patient was reassured. The patient recovered vocal cord movement 8 weeks after surgery, and speech was restored 12 weeks after the operation.
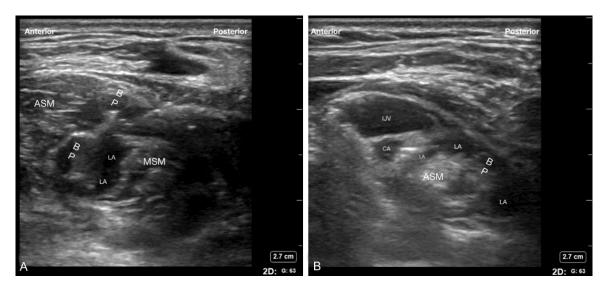
Keywords: Brachial plexus block, hoarseness, phrenic nerve, recurrent laryngeal nerve, recurrent laryngeal nerve injuries, vocal cord paralysis

Introduction

Interscalene brachial plexus block (IBPB) is widely used for anesthesia and pain management for shoulder, clavicle, and humerus surgery because of its ability to quickly and safely block nerves with a relatively low local anesthetic (LA) dose using ultrasound and a nerve stimulator (NS) [1]. IBPB offers many advantages over general anesthesia, including shorter hospital stay, reduced postoperative analgesia requirements, and avoidance of the risks and side effects of general anesthesia. Some of the well-known complications of IBPB include infection, hematoma, vascular puncture, local anesthetic toxicity, nerve injury, total spinal anesthesia, Horner's syndrome, and diaphragmatic paralysis. As complications of IBPB, phrenic nerve palsy and Horner's syndrome are relatively common and well known, but vocal cord paraly-

sis, dysphonia, and airway obstruction rarely occur and are not well known. Hoarseness is a rare complication, and most cases are caused by the recurrent laryngeal nerve (RLN) being blocked. As the brachial plexus, proximal stellate ganglion, phrenic nerve, and RLN are concentrated at the IBPB site; these complications may arise from IBPB. However, most cases are known to recover within a few hours [2, 3]. As we experienced a case of ipsilateral vocal cord paralysis that lasted for several months after IBPB for a clavicle surgery, we are reporting the case with a review of the literature.

Case

A 37-year-old woman (weight 70 kg and height 167 cm) was transferred to our hospital with a left clavicle fracture from a traffic accident. The patient had a pneumothorax and a hemothorax

Figure 1. Ultrasound image immediately (A) and 5 minutes (B) after interscalene brachial plexus block. Local anesthetics is spread to anterior scalene muscle and carotid artery. ASM: anterior scalene muscle. BP: brachial plexus. CA: carotid artery. IJV: internal jugular vein. LA: local anesthetic. MSM: middle scalene muscle.

along with second and third rib fractures on the left side. Thus, a chest tube was inserted on the day of the accident. The patient received follow-up care for right thyroid goiter and had undergone two cesarean sections. The patient decided to receive open reduction and internal fixation of the left clavicle on day 9 after the accident. A preoperative chest X-ray showed second and third rib fractures on the left side. Other preoperative evaluations revealed no specific findings. Regional anesthesia using IBPB was explained, and informed consent was obtained as the patient refused general anesthesia. No premedication was given before anesthesia.

Electrocardiography (ECG), non-invasive blood pressure (NIBP) monitoring, and pulse oximetry were used in the operating room. After identifying the insertion site with ultrasound, dual-guided (ultrasound and NS-guided) IBPB was performed with the patient in the supine position and the head facing away from the side to be blocked. The skin was disinfected. The ultrasound probe and cable were protected with a sterile US probe cover (Sono Lab™ 18 × 120 cm, Lucky Medical, Seoul, Korea). Transportable US equipment with a 25 mm linear 6-13 MHz probe (SonoSite X-PORTE™; SonoSite Inc., Bothell, WA, USA) was used. The probe was positioned in the transverse plane to identify the carotid artery. Once the artery was identified, the probe was moved laterally across the

neck. The probe was then moved cranially and caudally. The goal was to identify the scalene muscles and the brachial plexus that was sandwiched between the anterior and middle scalene muscles just below the level of the transverse process of the seventh cervical vertebra. A 22G stimulating needle (Stimuplex® D, B. Braun, Melsungen, Germany) was inserted in-plane toward the brachial plexus in a posterior-to-anterior direction. Current was slowly decreased from 2.0 to 0.2 mA by 0.1 mA intervals until the muscle twitch disappeared. A 5 ml aliquot of 0.375% ropivacaine was injected into the posterior cervical space for the supraclavicular nerve block. Then, 30 ml of 0.375% ropivacaine was injected into the brachial plexus (**Figure 1**). The degree of sensory block was measured using a blunt needle 10 min after the injection, and sensory block was clearly observed. There were no signs of dyspnea, hypotension, or bradycardia. Pulse oxygen saturation (SpO_2) was maintained at $\geq$ 99%. Oxygen was supplied at 5 L/min using a facial mask after changing the patient's posture to the beach chair position. Propofol was infused continuously using target controlled infusion (Orchestra®, Fresenius Vial, Brézins, France) by setting it to the Schnider model according to the patient's desire to be sedated.

The operation lasted 1 hour, and anesthesia time was about 1 hour and 40 min. During anesthesia and the surgery, the patient did not

Figure 2. Laryngoscopic images after surgery. Left vocal cord (arrow) is paralyzed.

complain about discomfort and no serious side effects were encountered. In the recovery room, the patient did not complain about discomfort, the vital signs were stable, and SpO_2 was maintained > 97%.

After being transferred to the ward, the patient complained about not being able to talk. She realized that she was unable to speak immediately after the operation but neglected to inform the medical staff as she thought the inability to talk was due to pain from the rib fracture and the chest tube. Additionally, her voice became so slight that it could hardly be heard and she had a hard time saying more than one word consecutively. In addition, standing up from sitting down caused shortness of breath. She kept choking on her food while trying to eat and it caused discomfort.

A postoperative chest X-ray revealed that the left diaphragm was elevated 1-2 cm compared to the preoperative image. A laryngoscopic test performed by an otolaryngologist showed decreased left vocal cord movement (**Figure 2**). Ipsilateral vocal cord paralysis was explained and the patient was reassured with plans of further observation. A month after the operation, the patient complained about aspiration and how she still felt uncomfortable speaking during the ear, nose, and throat follow-up. Testing revealed a decrease in vocal cord movement. Eight weeks after the operation, the patient showed vast improvement in vocal cord movement. By 12 weeks after the operation, vocalization was improved enough to not cause any problems while speaking.

The patient planned to undergo an operation to remove the inserted plate 6 months after the surgery. However, she was strongly against general anesthesia, so we decided to perform regional anesthesia after an extensive explanation about the procedure and obtaining consent.

After the patient arrived in the operating room, ECG, the NIBP monitor, and a pulse oximeter were attached. After carefully examining the anatomical structures, such as the brachial plexus, phrenic nerve, and RLN by ultrasound (**Figure 3**), 4 ml of anesthesia was injected into the posterior cervical space at a level slightly lower (caudad) than the previous IBPB level. Then, 3 ml was injected into the lateral side of the superior trunk (low IBPB). IBPB was performed with a single skin puncture and needle manipulation (single penetration double-injection technique) (**Figure 4**). The drug was carefully injected to prevent it from spreading into the anterior scalene muscle (ASM).

Measuring the degree of sensory block of the surgical site 10 min after the injection showed a clear effect. There was no sign of deterioration in vocalization, dyspnea, hypotension, or bradycardia. No sign of phrenic nerve palsy was detected on US in the recovery room. After confirming that there was no problem, the patient was moved to the ward and was discharged without any significant complaints.

Discussion

IBPB is widely used as perioperative analgesia and anesthesia during clavicle or shoulder surgery [1]. Some of the well-known complications of IBPB include infection, hematoma, vascular puncture, local anesthetic toxicity, nerve injury, total spinal anesthesia, Horner's syndrome, and diaphragmatic paralysis [4]. However, hoarseness (vocal cord paralysis) may occur as well [5]. Hoarseness is a rare complication that occurs in 3% of patients during IBPB or subclavian perivascular block and most cases are caused by the RLN being blocked [4].

Phrenic nerve palsy is known to occur almost 100% of the time when performing IBPB [2]. The phrenic nerve from cervical nerve roots 3-5 enters the thoracic cavity while running vertically on the ASM surface. Because the phrenic nerve runs on the front side of the ASM at the
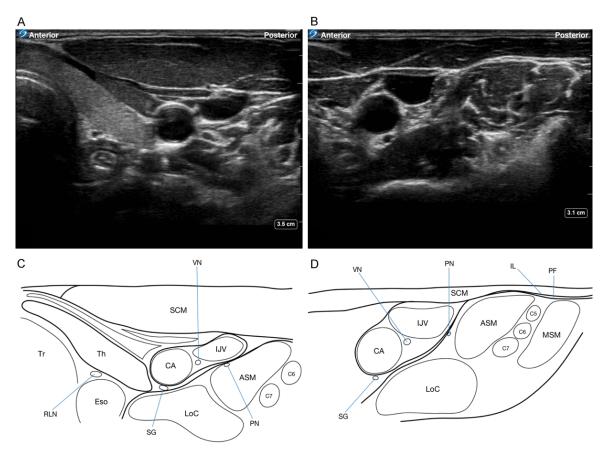
Figure 3. Ultrasound images (A, B) and their corrosponding schematic representation (C, D) at the site of interscalene brachial plexus block. The recurrent laryngeal nerve, Stellate ganglion and phrenic nerve are close to the brachial plexus. The posterior cervical space is beween investing layer and prevertebral fascia. ASM: anterior scalene muscle. C5, 6, 7: brachial plexus. CA: carotid artery. Eso: esophagus. IL: investing layer (superficial cervical fascia). IJV: internal jugular vein. LA: local anesthetic. LoC: longus colli muscle. MSM: middle scalene muscle. PF: prevertebral fascia. PN: phrenic nerve. RLN: recurrent laryngeal nerve. SCM: sternocleidomastoid muscle. SG: Stellate ganglion. Th: thyroid. Tr: trachea. VN: vagus nerve.

site where IBPB is performed, spreading of the LA on the ASM results in phrenic nerve palsy (**Figure 3**) [6].

A similar mechanism may also result in RLN palsy. The RLN is branched from the vagus nerve and the right side rotates on the lower part of the subclavian artery. The left side rotates on the lower part of the aortic arch. They each travel upward between the trachea and esophagus and enter the larynx through the cricothyroid membrane. The RLN is located just below the thyroid gland and adjacent to the carotid artery at the site where IBPB is performed (**Figures 3**, **5**). Once the LA has spread to the ASM, it could reach the site.

In fact, brachial plexus, phrenic nerve, and RLN are not very distant structures (**Figures 3**, **5**). Kessler et al. observed the phrenic nerves in

23 patients using US. Their findings indicated that the distance between the BP and phrenic nerve was 0.18-0.2 cm at the cricoid cartilage; thus, they were nearly attached. Measuring the distance 3 cm below the cricoid cartilage results in 1.08-1.16 cm [7]. In our case, the distance between the brachial plexus and RLN were estimated to be 3 cm on US (**Figure 3**). Checking US immediately after IBPB revealed that the injected LA spread over the ASM and down to the lower section of the carotid artery (**Figure 1**). Therefore, phrenic nerve palsy, Horner's syndrome, and RLN palsy may have occurred.

As these structures are separate from each other and exist in different compartments, LA does not generally spread easily to the RLN (**Figure 5**). The RLN is located between the trachea and esophagus posterior to the thyroid
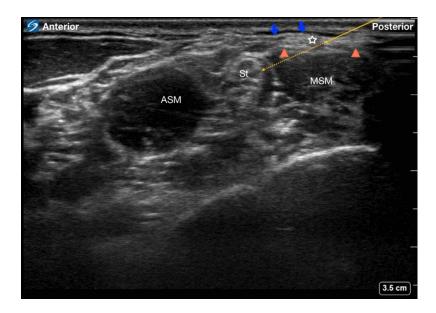
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Figure 4. The single-penetration double-injection technique for the low inter-scalene brachial plexus block. The orrange dotted arrow is needle trajectory of the single-penetration double-injection technique with one injection into the posterior cervical space and the other lateral to the superior trunk. Arrow (blue): investing layer (superficial cervical fascia). Arrow head (red): prevertebral fascia. ASM: anterior scalene muscle. Dotted arrow line (orrange): needle trajectory. MSM: middle scalene muscle. St: superior trunk. Star: posterior cervical space.

[10]. Whether it is congenital or acquired, the risk of RLN palsy increases if there is a deficiency in tracheal fascia, prevertebral fascia, or the carotid sheath.

In addition to these anatomical factors, anesthesiological factors may also cause RLN palsy. The drug will spread farther if a large volume of anesthetic is used or if injection pressure is high. In addition, the injected drug may spread to undesired areas if careless needle manipulation leads to penetration of the carotid sheath or fascia in front of the ASM.

In this case, the primary cause of RLN palsy is thought to be injecting a large volume of LA; we injected 30 ml of LA, which is not a small volume, so that it would spread to the ASM. Therefore, we think the drug spread to the path of the RLN. Defects in the carotid sheath are unknown, but if there was a defect, the drug could have spread inside causing RLN palsy with a vagus nerve block.

gland and is protected by pretracheal fascia. The vagus nerve is surrounded by the carotid sheath along with the carotid artery and internal jugular vein. The ASM, brachial plexus, MSM, and phrenic nerve are surrounded by prevertebral fascia. In order for LA injected during IBPB to reach the RLN, it must go through barriers, including the ASM, prevertebral fascia, and pretracheal fascia.

Some relevant studies were summarized in **Table 1**. Knoblanche reported that the thin fascia of the ASM was the only obstacle preventing the spread of LA to the phrenic nerve during the IBPB procedure [8]. However, as phrenic nerve palsy occurs almost 100% of the time during a typical IBPB, the thin fascia of the ASM does not play a significant role. In addition, drug injected for a superficial cervical plexus block may extend beyond the deep cervical fascia to the deep cervical space [9], suggesting that fascia cannot completely prevent the drug from spreading.

Anatomical abnormalities can also be a cause of RLN palsy during IBPB. Shakespeare and Tsui experienced hoarseness in a continuous IBPB patient due to a deficient carotid sheath

As the patient's symptom lasted for 2-3 months followed by a complete recovery, the cause was likely a nerve conduction delay or neurapraxia, and not axonal injury. Neurapraxia is the mildest form of injury, affecting the surrounding Schwann cells, but the integrity of the axon remains intact. The result is a conduction block lasting 6-8 weeks followed by a complete return of function when the Schwann cells have been repaired [11].

Precautions for performing IBPB include the following. A large volume of LA should not be injected, as it is known to cause phrenic nerve palsy nearly 100% of the time even if as little as 20 ml of LA is used to perform IBPB between the C5 and C6 roots [12]. Minimize manipulation of the needle when possible. Unnecessary needle manipulation can damage anatomical defenses, such as fascia, and unintentionally cause the LA to spread to distant sites. Needle
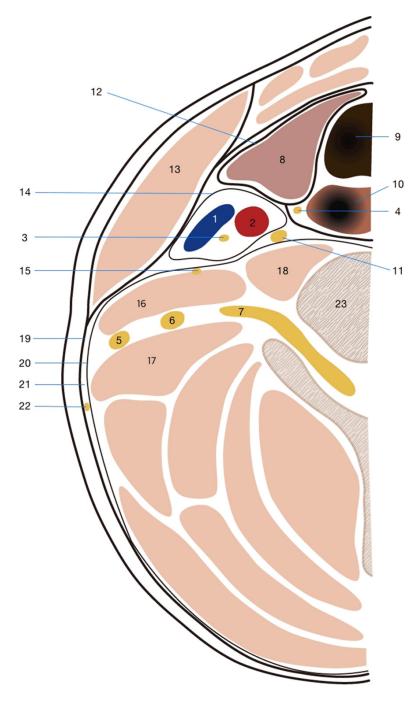
nerve and the superior trunk (single-penetration double-injection). It is better to prevent the needle and LA from going towards the ASM, which is anterior to the nerve [13]. It might be safer to perform IBPB at a site which is more distal/peripheral [14]. Performing IBPB at the trunk level rather than the root level is considered safer because it is farther away from the brachial plexus, phrenic nerve, and RLN. In our case, 3 ml of LA was used for the block at the superior trunk level where the ventral rami of C5 and C6 are fused. The operation ended without any complications, such as phrenic nerve palsy. However, as the present case involved clavicle surgery, no middle trunk block was needed, but it would be safer to consider this method in cases of shoulder surgery when the middle trunk also needs to be blocked [15].

Finally, preoperative anesthetic assessment should be performed thoroughly before performing IBPB. Vocal cord paralysis caused by an RLN block in IBPB occurs rarely in 3% of cases. Clinical significance is rare, as most cases occur unilaterally and recover within several hours [4]. Unlike bilateral vocal cord paralysis, which induces dyspnea, the major symptom of unilateral vocal cord paralysis is hoarseness, which affects the quality of the voice but is not life threatening [16]. However, a patient who already has vocal cord paralysis on the opposite side of the planned IBPB may experience severe dyspnea

Figure 5. The schematic representation of transverse section of neck. 1: internal jugular vein. 2: carotid artery. 3: vagus nerve. 4: recurrent laryngeal nerve. 5-7: 5-7th brachial plexus roots. 8: thyroid. 9: trachea. 10: esophagus. 11: Stellate ganglion. 12: pretracheal fascia. 13: sternocleidomastoid muscle. 14: carotid sheath. 15: phrenic nerve. 16: anterior scalene muscle. 17: middle scalene muscle. 18: longus colli muscle. 19: investing layer (superficial cervical fascia). 20: prevertebral fascia. 21: posterior cervical space. 22: supraclavicular nerve. 23: C7 vertebrae.

manipulation was minimized for the second operation in the present case by using a single penetration to block both the supraclavicular

Table 1. Additional blockades of nerve blocks

Study	Blockade	Additional blockade	Cause (suggestion)
Knoblanche et al.	Brachial plexus block	Phrenic nerve	Fascia of the ASM
Pandit et al.	Superficial cervical plexus block	Phrenic nerve	Deep cervical fascia
Shakespeare et al.	Continuous brachial plexus catheter infusion	Recurrent laryngeal nerve	Carotid sheath defect

ASM: anterior scalene muscle.

and airway obstruction if the RLN is blocked by IBPB [17]. Patients with a history of neck and thyroid surgery, or a history of radiation therapy to the neck or upper chest may already have vocal cord paralysis. Thus, an airway evaluation must be conducted prior to surgery and anesthesia [5]. If IBPB is planned for these patients, it should be performed very carefully because it is difficult to predict where the LA will spread to if the normal anatomical defense structures are damaged.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Young Duck Shin, Department of Anesthesiology and Pain Medicine, Chungbuk National University Hospital, College of Medicine, Chungbuk National University, 776, 1Sunhwan-ro, Seowon-Gu, Cheongju 28644, Chungbuk, Korea. Tel: +82-10-5482-0133; Fax: +82-43-272-0264; E-mail: yydshin@naver.com

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