RESPIRATORY FAILURE AFTER ACCIDENTAL PHRENIC NERVE BLOCK IN REGIONAL ANESTHESIA OF THE BRACHIAL PLEXUS VIA INTERSCALENE

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ABSTRACT

Objective: To describe a form of ventilatory complication resulting from regional anesthesia of the brachial plexus, accidental blockade of the phrenic nerve and its consequences on the respiratory system. Methodology: This is a descriptive study, in the format of a case report, carried out in Goiânia-GO. Data were collected through analysis of electronic medical records. The collected information was discovered with the pre-existing literature through the search of correlated articles in the PubMed/Medline and SCIELO database. Case report: A 42-year-old patient with severe sequelae and total limitation of movement of him right arm because of a car accident, attended for care of the left rotator cuff via arthroscopy, received general balanced anesthesia and regional anesthesia guided by ultrasound via interscalene and who in the post-anesthesia recovery room evolved with acute respiratory failure as a result of the right frantic nerve block. The patient was maintained on ventilatory support until the end of the effect of regional anesthesia and recovery of respiratory function. Conclusion: The patient reported here presented significant ventilatory dysfunction and diaphragmatic paralysis, due to possible involvement of the phenic nerve, after performing an interscalene block for arthroscopic surgery of the brachial plexus. Thus, he could have benefited from a supraclavicular blockade, which provides satisfactory analgesia and less chance of blocking the phrenic nerve, or in the case of maintaining the choice for the interscalene route, the blockade could have been performed with the lowest volume and concentration of local anesthetics.

KEYWORDS: ANESTHESIA, CONDUCTION; ANESTHETICS, LOCAL; ANESTHESIA RECOVERY PERIOD; PHRENIC NERVE; RESPIRATORY INSUFFICIENCY; POSTOPERATIVE COMPLICATIONS.

INTRODUCTION

Peripheral nerve blocks have seen a great resurgence of interest in the last decade, especially with the advent of ultrasound. Nerve blocks evolved from an art that only a few physicians could master to something with more objective results and transferable skill, due in large part, as already mentioned, to the introduction of ultrasound guidance. Peripheral nerve blocks are today a main component of perioperative multimodal analgesia [1,2]. In particular, for upper limb surgery, brachial plexus blocks (interscalene, supraclavicular, infraclavicular, and axillary approaches) have been consistently associated with anesthesia, with better time efficiency, faster recovery, fewer adverse events, better analgesia, and greater acceptance. of the patient [3-4].

Interscalene brachial plexus block is well established in shoulder surgeries, as it offers adequate postoperative anesthesia and analgesia. Traditionally, it provides a significant postoperative analgesic benefit. However, when used as a single-dose approach, it is limited by its duration [5], not lasting longer than 24 hours, even when using longer-acting local anesthetics such as bupivacaine [6].

In the context of shoulder surgery, interscalene nerve block is the most commonly used regional anesthetic technique [7,8], however, unintentional phrenic nerve block may be associated with this route of regional anesthesia. The blocked phrenic nerve generates ipsilateral diaphragmatic paralysis, which is temporary and usually asymptomatic in healthy patients. However, patients with limited ventilatory function or a disorder of the contralateral phrenic nerve may have severe respiratory symptoms.

The present study presents the case report of a patient who developed severe acute respiratory failure in the immediate postoperative period of shoulder surgery, and through this report we sought to explore, based on the pre-existing literature, forms of treatment and prophylaxis for this condition.

CASE REPORT

Male patient, 42 years old, ASA II, controlled hyperten-

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sion, smoker, with severe sequelae and total limitation of right arm movement resulting from brachial plexus injury after an automobile accident in 2002, with rotator cuff syndrome and chronic shoulder pain left due to loosening of the synthesis material installed for the treatment of a fracture of the left proximal humerus in 2018.

Having verified the loosening of the internal fixation plate of the left humerus with maintenance of fracture alignment, the orthopedics team indicated surgical treatment for removal of the material and repair of the rotator cuff, which surgery took place in the morning on March [9], 2022.

In the operating room, the patient was properly monitored with a pulse oximeter with plethysmographic curve, cardioscopy and non-invasive blood pressure, with stable vital signs before anesthetic induction and received venipuncture with a 20G needle in the right upper limb.

The patient was submitted to balanced general anesthesia: Pre-oxygenation under facial mask with oxygen at 100% 6L/min for 3 minutes, for venous anesthetic induction, 30mcg of sufentanil and 200mg of propofol were administered and after the loss of consciousness was verified, they were administered 50mg of rocuronium, the patient received manual ventilation until complete muscle relaxation and then orotracheal intubation was performed with an endotracheal tube in volume-controlled mode, with protective parameters, with fraction of inspired oxygen (FiO2) of 50%. Maintenance of general inhalational anesthesia was established by administration of sevoflurane at a concentration of 2% in low flows of fresh gases 2L/min in the anesthesia machine.

For regional anesthesia, the patient was positioned with the head elevated at 30° and the head lateralized to the right and after asepsis of the region with alcoholic chlorhexidine, an ultrasound-guided puncture was performed with abocath 18g to block the left brachial plexus via interscalene, the path of the needle was completely visible at all times, aspirations were performed before the infusions without blood return, a total of 20ml of an anesthetic solution consisting of 10ml of 2% lidocaine with 1:200,000 epinephrine were infused through the region and 10ml of levobupivacaine 0.5% with epinephrine 1:200,000 totaling 200mg of lidocaine, 50mg of levobupivacaine and 100mcg of epinephrine.

The intraoperative period was uneventful and the patient maintained stable vital signs throughout the period. At the end of the surgery, which lasted two hours, the patient was decurarized with 2mg of neostigmine and 1mg of atropine, and when adequate ventilatory parameters were reached in spontaneous breathing, extubation was performed. Then, the patient was taken to the post-anesthesia care unit (PACU), awake, conscious, without complaints, using a nasal catheter with oxygen at 2L/min, eupneic and with peripheral oxygen saturation of 99% before leaving the operating room.

In the PACU, the patient evolved with acute respiratory failure, with progressive dyspnea and desaturation, verified by pulse oximetry, in the amount of 56% on the monitor. The assistant anesthesia team opted for venous induction in rapid sequence intubation with 200mg of propofol, 100mcg of fentanyl and 100mg of rocuronium. After orotracheal reintubation with a 7.5 tube, mechanical ventilation started in volume-controlled mode, with protective parameters and with an inspired fraction of oxygen of 60%, there was a progressive improvement in peripheral oxygen saturation, returning to the value of 99% indicated on the monitor.

With the stabilization of the clinical picture, the patient was taken to the computed tomography of the hospital, for diagnostic purposes. Chest angiotomography with contrast and chest X-ray were performed, represented by figure 01, below:

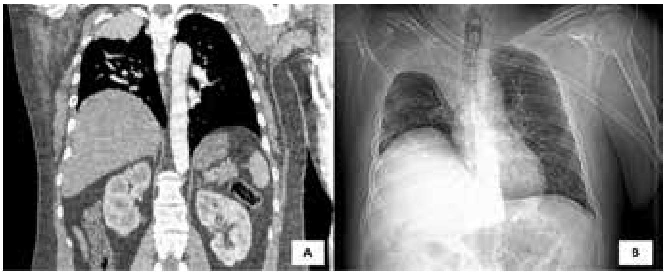

Figure 01. Images of the patient. A. CT angiography of the chest showing elevation of the right diaphragmatic dome and almost complete atelectasis of the upper lobe of the right lung. B. Chest X-ray showing the same CT findings

Chest angiotomography (Figure 01.A) showed elevation of the right diaphragmatic dome and almost complete atelectasis of the upper lobe of the right lung, in addition to atrophy with marked liposubstitution of the muscles of the shoulder girdle and right chest wall, findings compatible with the chronic lesion of ipsilateral brachial plexus. There was also the presence of bilateral pulmonary atelectatic opacities, predominating in its posterior portions; the other pulmonary fields did not present alterations. Signs of pulmonary thromboembolism were ruled out, there were no perfusion failures in the pulmonary trunk, in the main pulmonary arteries or in their lobar and segmental branches.

Thus, the main diagnostic hypothesis for the picture of acute respiratory failure presented by the patient in the PACU was accidental blockade of the left phrenic nerve after regional anesthesia of the brachial plexus via interscalene, leading to ipsilateral diaphragmatic paralysis, which caused respiratory fatigue that was not compensated because of the pre-existing contralateral pulmonary dysfunction and morphofunctional sequelae resulting from complete and chronic injury to the brachial plexus and right phrenic nerve.

The patient was transferred to the intensive care unit, where he remained monitored, under ventilatory support and clinically stable. In the late afternoon of the same day, the patient recovered respiratory function with the end of the effect of the local anesthetics used in regional anesthesia and was successfully extubated, without presenting new episodes of dyspnea or desaturation, maintaining peripheral oxygen saturation of 95% in use of supplemental oxygen 2L/min through a nasal catheter. During the 48 hours after extubation, treatment was performed with respiratory physiotherapy and intermittent non-invasive ventilation with the aim of lung re-expansion. The patient had a good evolution of respiratory function with progressive improvement in oximetry, without the need for supplemental oxygen, maintaining a peripheral saturation of 99% on room air, and was discharged from the ICU to his home on March 12, 2022.

DISCUSSION

The brachial plexus is a nerve network that supplies the upper extremity of the human body, formed by nerve roots from C5 to T1. It emerges from the cervical spine and travels between the anterior and middle scalene muscles and distally around the axillary artery. Interscalene brachial plexus block is a common practice for procedures on the distal clavicle, shoulder and proximal humerus, as it ensures excellent anesthetic coverage and postoperative analgesia. The space between the scalene muscles is called the interscalene groove. This space is palpable behind the lateral head of the sternocleidomastoid muscle and adjacent to the lateral tubercle of C6, also known as the Chaissaignac's tubercle [9]. In fact, interscalene brachial plexus block is the most used postoperative analgesic technique in shoulder surgery. In addition to postoperative analgesia, it reduces pain scores and opioid consumption. However, it has disadvantages and contraindications, including short duration of analgesia, rebound pain, high incidence of unilateral diaphragmatic paresis, and potential risk of nerve damage when targeting nerve roots in the neck rather than peripheral nerves [10].

The interscalene block covers most of the brachial plexus, sparing the ulnar nerve (C8-T1). The interscalene space is identified by palpation or ultrasound visualization. Under ultrasound visualization, the brachial plexus can typically be seen as 2 or 3 hollow circles ("traffic lights") that correspond to the upper, middle, and lower trunks. The lower trunk can sometimes be difficult to visualize as the muscle thickens. Once visualized, injection of a long-acting local anesthetic can block nerve impulses and cause upper extremity numbness and weakness. Structures immediately distal to nerve block placement consistently block nerve impulses and cause sensory and movement loss [9].

A nerve stimulator can also be used as an adjunct to confirm placement. The nerve stimulator causes muscle contractions in the deltoid muscle, arm or forearm when the corresponding nerve is stimulated. A volume of local anesthetic is injected, usually between 15 and 25mL. Commonly used local anesthetics include bupivacaine and ropivacaine. After injection of the anesthetic, the patient presents pain relief and a feeling of heaviness in the limbs during the action of the local anesthetic [9].

Among the complications of this blockade route are described: postoperative neurological symptoms, vascular complications (bruises, intravascular injections leading to systemic intoxication by local anesthetics), respiratory complications (pneumothorax), epidural or subarachnoid injection, undesirable blocks (Horner syndrome generating miosis, palpebral ptosis and anhidrosis when blocking the cervical sympathetic chain, dysphonia due to vocal fold paralysis when blocking the recurrent laryngeal nerve and alteration of the diaphragmatic function when blocking the phrenic nerve). This block is contraindicated in patients with respiratory failure due to the high probability of ipsilateral phrenic nerve block and diaphragmatic hemiparesis. This can lead to a 25% reduction in lung function. Due to unilateral diaphragmatic paresis, respiratory mechanics can be considerably impaired [9,11]. The phrenic nerve arises from the C3-C5 nerve roots of the deep cervical plexus, passes over the anterior surface of the anterior scalene muscle, and descends into the thoracic cavity, providing motor innervation to the ipsilateral hemidiaphragm. When performing an interscalene block, due to its proximity to the target nerve, the phrenic nerve is typically blocked inadvertently by ventral spread of the local anesthetic. The same may occur, however, with lower incidence, in subclavian perivascular blocks [12].

In healthy adult patients transient unilateral diaphragmatic paralysis is tolerated and generally asymptomatic. It is possible that the accessory muscles compensate for the restriction imposed by the paralysis and the expansion of the contralateral lung manage to produce enough negative pressure to guarantee good ventilation [13]. Based on studies, it can be assumed that patients with ASA II (less than or equal) without pre-existing pulmonary disease are not clinically impaired by a phrenic nerve block induced by an interscalene block, with subsequent hemidiaphragmatic paresis. Despite the paresis, they can be transferred directly from the operating room to the general care unit, as long as they have an Aldrete and Kroulik score of 10 (a scale used to assess the post-anesthetic recovery of patients undergoing anesthesia) when leaving the operating room [11]. However, severe respiratory symptoms may appear in patients with limited pulmonary reserve or previous pulmonary dysfunctions (obese, asthmatic, patients with chronic obstructive pulmonary disease, elderly) and the blockade is contraindicated in the presence of deficit of the contralateral phrenic nerve, since blocking the functioning phrenic nerve may result in severe respiratory distress or respiratory arrest. [14]. In cases of bilateral shoulder surgeries, due to the risk of total diaphragmatic paralysis, bilateral interscalene blocks are not recommended [15].

Due to the hypothesis that the phrenic nerve block occurs by dispersion of the local anesthetic to the anterior region of the anterior scalene, it is presumed that by reducing the volume and concentration of the anesthetic solution used in the interscalene block, there is a limitation of the amount of local anesthetic capable of reaching the region of the phrenic nerve, thus reducing side effects of respiratory function. Ultrasound guidance allows using a smaller volume of local anesthetic and depositing it more precisely, leading to a reduction in the incidence of hemidiaphragmatic paralysis and other side effects, as the trajectory of the needle can be tracked and controlled in real time, minimizing the risk of trauma to critical structures including nerves, vessels and pleura [16].

Riazi et al compared the efficacy and respiratory consequences of ultrasound-guided interscalene brachial plexus blocks using 5ml and 20ml of 0.5% ropivacaine. The incidence of diaphragmatic paralysis due to phrenic nerve block was 45% in the low volume group and 100% in the 20ml group. There were no significant differences in pain scores and opioid consumption 24 hours after surgery [17]. Renes et al determined that the minimum effective volume of 0.75% ropivacaine for shoulder analgesia in ultrasound-guided C7 root block was 2.9 ml in 50% and 3.6 ml in 95% of the patients studied. The lung function of this sample remained unchanged up to two hours after the completion of the surgery [18]. Gautier et al showed that the minimum effective anesthetic volume of 0.75% ropivacaine for adequate surgical analgesia for shoulder arthroscopy with interscalene brachial plexus block was only 5 ml or 1.7 ml for each of the upper, middle and lower trunks of the brachial plexus [19]. Such evidence suggests that the use of low-volume local anesthetics for the interscalene block provides adequate analgesia for shoulder surgeries and at the same time reduces the incidence of phrenic nerve block and its repercussions on the respiratory system.

Bergmann et al performed a randomized clinical trial of 84 patients scheduled for elective shoulder surgery, divided into two groups to receive an ultrasound-guided approach to interscalene brachial plexus block via the anterior (n = 42) or posterior (n = 42) approaches. Both groups received 15 ml of 1% ropivacaine. Spirometry was performed at baseline and 30 min after blockade [11]. Spirometric results showed a significant decrease in vital capacity, forced expiratory volume in the first second and maximum nasal inspiratory capacity after interscalene brachial plexus block; indicating a phrenic nerve block. Despite changes in spirometry, no case of dyspnea was reported. The authors mention in their discussion that the respiratory/clinical effects of phrenic nerve blocks are usually well compensated. It was not possible to identify a significant difference in the impairment of spirometric parameters between the group that used the anterior route and the group using the posterior route [11].

Since the phrenic nerve block was considered an inevitable consequence of the interscalene block [20], comparative studies have appeared in relation to the effectiveness of the supraclavicular block of the brachial plexus in substitution of the interscalene block, for shoulder surgeries, in order to reduce the incidence of diaphragmatic paralysis, since there is less occurrence of this complication in supraclavicular blocks. Hussain et al showed that interscalene block offers an analgesic advantage limited only to the immediate postoperative period (post-anesthetic recovery room) and that supraclavicular and interscalene blocks did not present statistical differences in pain severity and opioid consumption in the first 24 hours after shoulder surgery. Given the above data, patients with a risk factor for respiratory failure with a phrenic nerve block may benefit from choosing the supraclavicular approach for brachial plexus block [20].

A review carried out by Kang and Ko in 2023 corroborates the benefit of the brachial plexus block via the supraclavicular route, which can be considered an effective and safe alternative to shoulder surgery, especially in patients with preexisting pulmonary impairment. When performing supraclavicular brachial plexus block, the incidence of hemidiaphragmatic paresis was effectively reduced when local anesthetic was injected primarily into the corner pouch (20 ml) and secondarily into the neural cluster (5 ml) during right-sided supraclavicular brachial plexus block. Other alternatives to avoid phrenic nerve block, suggested in this review, were extrafascial injection for interscalene blocks, with the potential to reduce the incidence of hemidiaphragmatic paresis and consequently preserve lung function, while providing analgesia similar to a conventional intrafascial injection. Furthermore, this may reduce the potential for neurological injury inherent to the interscalene brachial plexus block [10].

Another alternative is the injection around the upper trunk of the brachial plexus. The upper trunk is formed by the fusion of the C5 and C6 nerve roots. Therefore, local anesthetic injection around the upper trunk should produce similar analgesia in the shoulder, because the main terminal nerves innervating the shoulder arise distal to the upper trunk. Furthermore, the injection site is farther from the phrenic nerve, which theoretically reduces the risk of hemidiaphragmatic paresis. Studies have shown similar pain scores, duration of analgesia and opioid consumption in 24 hours, and less frequent hemidiaphragmatic paralysis in the upper trunk block group [10]. One more strategy to reduce the risk of hemidiaphragmatic paresis would be to inject local anesthetic into the terminal nerves of the shoulder, more distally to the upper trunk. A shoulder block is an alternative approach that blocks the suprascapular and axillary nerves. These two nerves innervate most of the shoulder, with additional minor contributions from the subscapular and lateral pectoral nerves. Suprascapular and axillary nerve blocks reduced the incidence of hemidiaphragmatic paresis and pulmonary dysfunction while providing similar postoperative analgesia [10].

Addition of liposomal bupivacaine is a viable option without refining the interscalene brachial plexus block technique. The addition of liposomal bupivacaine to bupivacaine resulted in statistically significant reductions in diaphragmatic excursion and tested lung function 24h after block placement compared with bupivacaine alone. However, this reduction was within the range of normal diaphragmatic function [10].

The respiratory limitation imposed by the phrenic nerve block is a self-limiting event, therefore, the treatment consists of providing ventilatory support until the patient recovers respiratory function with the end of the action of the local anesthetic in the phrenic nerve region. There are reports of cases [21,22] of reversal of the phrenic nerve block with recovery of pulmonary function after the infusion of saline solution in the interscalene region, but the efficacy of this technique needs more consistent studies for its recommendation. The use of saline solution was also studied by Srinivasan et al as a form of prophylaxis for unwanted blockage of the phrenic nerve. Their study demonstrated a 50% reduction in the incidence of hemidiaphragmatic paralysis when filling the region anterior to the anterior scalene muscle with 10ml of saline solution before proceeding with the interscalene blockade [23]. The mechanisms underlying recovery from blockade or prophylaxis for phrenic nerve involvement are still not well understood, saline boluses can cause a dilution effect, a local pH reduction, alteration of the local sodium content or even a placebo effect [24], interfering with the effectiveness of the effect of the local anesthetic in the region, allowing the phrenic nerve to recover more quickly.

CONCLUSION

The interscalene brachial plexus block may have phrenic nerve block as a frequent complication. In populations with risk factors for respiratory failure, the choice of technique and blockade route should be a cautious decision. Given the above, the patient in the case report could have benefited from a supraclavicular block that provides similar analgesia and lower risk of involving the phrenic nerve. He could also, in case the interscalene route was chosen, have received a smaller volume of local anesthetics, in lower concentrations, with ultrasound help in order to precisely determine the injection site. Studies are still needed regarding prophylaxis of phrenic nerve involvement and reversal of unwanted blocks with the use of saline solution.

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