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Persistent diaphragmatic paralysis associated with interscalene nerve block after total shoulder arthroplasty: a case report

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Interscalene nerve blocks (ISBs) have become routine adjuncts to shoulder surgery because they have led to significant decreases in postoperative pain, reduced requirements for opioid pain medication, earlier mobilization, quicker hospital discharge, decreased unplanned hospital readmission, and increased patient satisfaction.^{1,4,6,11} Although ISBs are regularly performed, they are not without risk and carry an overall complication rate between 2% and 4%.⁹

Transient ipsilateral hemidiaphragmatic paralysis can be observed in association with ISB, and may transiently occur in up to 100% of patients because the phrenic nerve is close to the target brachial plexus nerve roots.^{1,6–8,13} However, persistent hemidiaphragmatic paralysis is exceedingly rare after ISB, with only limited case reports documenting longstanding decreases in respiratory function and, in some instances, compromise in the patient's overall functional capacity.^{5,7,8,13,14}

The etiology of persistent phrenic nerve dysfunction linked with ISB remains unclear, and numerous mechanisms have been proposed.^{5,7,8,13} We offer an illustrative case report of a patient with persistent ISB-associated diaphragmatic paralysis, while calling attention to this condition and identifying risk factors to accelerate accurate diagnosis and treatment with the goal of optimizing functional outcomes.

Case report

A 63-year-old man (body mass index, 30.8 kg/m²), without significant medical history, presented to the clinic with the complaint

of continued severe shortness of breath 1 year after left total shoulder arthroplasty (TSA) for primary glenohumeral osteoarthritis. An ultrasound-guided ISB was performed for regional anesthesia and postoperative pain control, and the patient underwent general anesthesia for the index operation in a modified beach chair position. The patient tolerated the surgery well, without complications, and received routine supportive postoperative care during his limited inpatient stay.

At the time of discharge, the patient reported no complaints. The physical examination findings on evaluation by the orthopedic and internal medicine care teams were normal. The patient tolerated the inpatient evaluation with physical therapy, and after he met appropriate functional criteria, he was discharged home on postoperative day 1.

At 6 weeks postoperatively, the patient began to experience worsening shortness of breath, prompting him to present to the hospital for an urgent evaluation (Table 1). In the emergency department, findings of a comprehensive work-up for pulmonary embolism were negative, but the chest computed tomography (CT) demonstrated a left-sided pleural effusion (Fig. 1).

The patient was placed in pulmonary rehabilitation by his primary care physician, with some subsequent improvement in his symptoms. He did, however, continue to report dyspnea and activity-related shortness of breath. Preoperatively, the patient had been running 5 km daily and golfing regularly without any respiratory issues. The patient now reported difficulty walking up 1 flight of stairs, mowing his lawn, or golfing more than 9 holes due to worsening shortness of breath.

A chest radiograph demonstrated an elevated left hemidiaphragm (Fig. 2), and a fluoroscopic sniff test confirmed paralysis of the left hemidiaphragm (Fig. 3). The consensus after consultation with cardiology and pulmonology teams was that the patient had sustained left diaphragmatic paralysis due to persistent phrenic nerve

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Table 1
Differential diagnosis and evaluation considerations for acute dyspnea in the post-surgical setting by organ system

Organ system	Diagnosis	Evaluation
Pulmonary	• Atelectasis	• Chest x-ray
	• Pulmonary embolism	• CT pulmonary angiogram
	• Pneumonia	• Ventilation/perfusion (V/Q) scan
	• Pleural effusion	• Lower extremity Doppler US
	• Sedation effects	• Electrocardiogram
Cardiovascular	• Myocardial infarction	• Chest x-ray
	• Congestive heart failure	• Echocardiogram
	• Hypovolemia	• Cardiac enzymes
	• Arrhythmia	• B-type natriuretic peptide
Neurologic	• Stroke	• CT brain
	• Nerve injury	• MRI/MRA head
Renal	• Acute kidney Injury	• Basic metabolic panel
		• Chest x-ray (fluid overload)
Endocrine	• Hyper-/hypoglycemia	• Blood glucose
	• Hypo-/hyperthyroidism	• Thyroid stimulating hormone
Infectious	• Sepsis	• Complete blood count
		• Erythrocyte sedimentation rate
		• C-reactive protein
		• Procalcitonin
		• Lactate
		• Urinalysis/urine cultures
	• Blood cultures	

CT, computed tomography; US, ultrasound; MRI, magnetic resonance imaging; MRA, magnetic resonance angiogram.

palsy thought to be associated with the ISB performed at the time of surgery.

Although the patient is pleased with the improvements in pain and mobility of his shoulder after TSA, he continues to have significant functional limitations due to shortness of breath. The patient was offered a referral for a neurosurgical consultation; however, he has chosen not to pursue further consultation at this time. The patient has continued with pulmonary rehabilitation in an attempt to improve his respiratory capacity and tolerance for activity. The prognosis for substantial recovery remains poor, however.

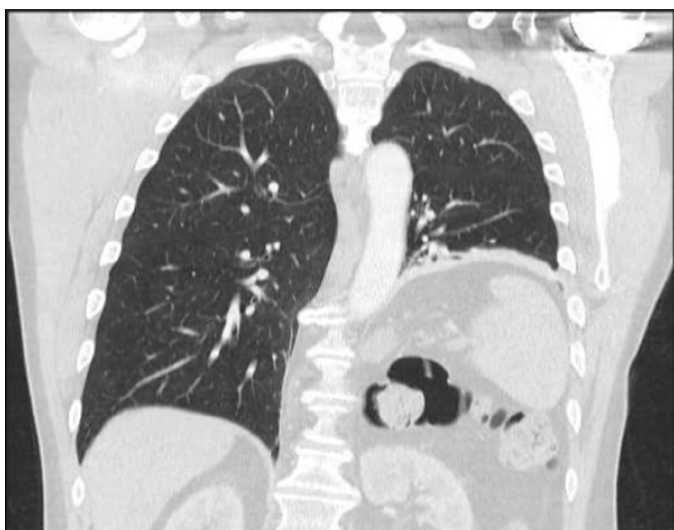


Figure 1 Chest computed tomography image without evidence of a pulmonary embolism. A left-sided pleural effusion is noted. Left hemidiaphragmatic elevation is also noted on this image. However, the radiology report did not mention this abnormality, and the computed tomography images were not initially available in our clinic during the work-up because the imaging was ordered by a subspecialist at another institution.



Figure 2 Anteroposterior chest radiograph shows an elevated left hemidiaphragm, which raised suspicion for left hemidiaphragm paralysis.

Discussion

Regional and neuraxial anesthesia are routinely used in shoulder surgery because they have been thoroughly documented to improve pain control, allow for earlier mobilization, decrease hospital length of stay, avoid hospital readmission, and improve patient satisfaction.^{1,4,6,11} A comprehensive knowledge of the anatomy of the cervical soft tissues and neurovascular structures is necessary for performing an effective and safe regional anesthesia block.

With the patient's head turned to the contralateral side, the interscalene groove should be palpated and marked at the level of C6. This can be accomplished by palpating the lateral border of the sternocleidomastoid muscle and moving laterally into the space between the anterior and middle scalene muscles. The brachial plexus in adults typically lies about 1 to 2 cm under the skin.³

A longer-acting anesthetic, such as ropivacaine, is typically used for an ISB. The anesthetic is injected in the perineural space around the brachial plexus nerve roots, preferentially targeted at the C5 to C7 levels.³ Temporary phrenic nerve paralysis is nearly ubiquitous due to the proximity of the phrenic nerve to the target brachial plexus nerve roots, with ipsilateral hemidiaphragmatic paralysis being reported in up to 100% of patients undergoing ISB, with quick diminution of its effects under close observation.^{1,6,8,13}

The accuracy of the injection can be increased with the aid of a nerve stimulator or ultrasound (US) guidance.^{1,3,6} With advancements in US-guided injections, the precision of ISB has greatly improved by allowing direct visualization of anatomic structures, allowing for more precisely targeted injections and decreasing the volume of medication needed to achieve proper anesthesia.^{3,6} Although there is evidence that US-guided ISB reduces the incidence and severity of hemidiaphragmatic paresis, there is no meaningful data to support a decreased incidence of peripheral nerve injury with use of US-guided regional anesthesia.^{10,12}

Studies have shown that ISBs result in a 20% to 25% decrease in forced vital capacity attributable to ipsilateral diaphragm paralysis associated with phrenic nerve involvement during an ISB. Healthy patients are able to compensate for this decrease in forced vital capacity by increasing their respiratory rate and using accessory respiratory muscles until the block wears off, which typically occurs within 3 to 5 hours.¹⁴ Caution should be taken in patients with pre-existing respiratory conditions because an ISB may predispose these

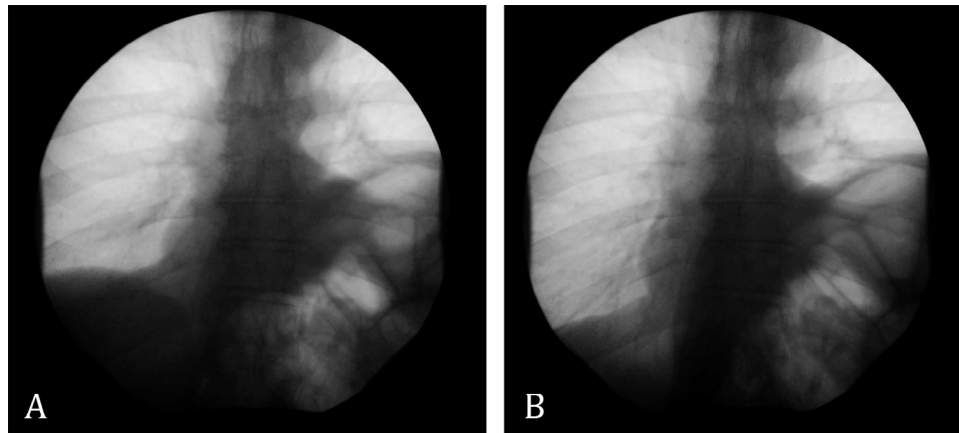


Figure 3 (A) Fluoroscopic sniff test during expiration with the left and right hemidiaphragms elevated. (B) Fluoroscopic sniff test during inspiration, which shows appropriate physiologic depression of the right hemidiaphragm but persistent elevation of the left hemidiaphragm.

patients to potential respiratory complications.^{1,6,7} Although rare, the occurrence of chronic respiratory symptoms is a possible severe complication that has been associated with the use of ISB. Therefore, supportive measures, including supplemental oxygen, airway access, and postoperative surveillance, are key in preventing respiratory complications associated with ISB.

In a study by Borgeat et al,² the most common complaints associated with ISB were pain, dysesthesias, or paresthesias not directly related to the operation (14%). Most of these symptoms were transient, however, and only 0.4% of patients went on to experience severe chronic complications, with long-term neurologic complication rates associated with brachial plexus blocks estimated to occur in less than 0.2% of patients.^{1,2} According to one study, persistent phrenic nerve palsy occurred in only 0.06% of patients who underwent ISB.⁹

Other acute complications associated with ISB are pneumothorax (0.2%), central nervous system toxicity (0.2%), and aspiration of blood during placement of the ISB (0.6%). Nonacute complications included cubital tunnel syndrome (1.5%), complex regional pain syndrome (1%), carpal tunnel syndrome (0.8%), plexus neuropathy (0.2%), and severe plexus damage (0.2%).² Horner syndrome, auditory disturbances, and recurrent laryngeal nerve palsy are also potential complications but are less commonly reported in the literature.^{3,9}

Although uncommon, persistent diaphragmatic paralysis from phrenic nerve injury associated with ISB has been described in multiple case reports.^{7,8,13,14} The exact etiology of phrenic nerve palsy associated with ISB remains unclear, and numerous theories have been proposed. Possible mechanisms include direct nerve trauma during the injection, neurotoxic effects of anesthetic medications, local ischemic changes, nerve compression from the volume of anesthetic used, nerve compression from paracervical hematoma formation, postsurgical adhesions and fascial thickening, and improper surgical positioning.^{5,7,8,13}

The etiology has yet to be determined in our patient's case, but is likely multifactorial. The surgical procedure itself is unlikely to be associated with persistent diaphragm paralysis because the phrenic nerve courses distant from the glenohumeral joint and is unlikely to be affected by direct manipulation during the surgical procedure or by postoperative swelling. Kaufman et al⁸ documented intraoperative findings consistent with compression neuropathy in a series of cases of persistent hemidiaphragm paralysis associated with ISB. Due to the course of the phrenic nerve and its position between the anterior scalene muscle and prevertebral fascia, it may be vulnerable to compression.⁸ Obesity may also complicate the ISB because it increases the difficulty of identifying

anatomic landmarks, even with the aid of US guidance. In addition, overweight or obese patients may have an underlying metabolic syndrome that could predispose them to the development of peripheral neuropathy.^{8,14}

Correctly diagnosing this condition is imperative because patients may benefit from pulmonary rehabilitation or surgical decompression, which is supported by recent evidence proposed by Kaufman et al⁸ that patients with this condition can benefit from surgical decompression with the possibility of nerve grafting. Their data demonstrated improvement in 69% of patients who underwent surgical treatment for permanent diaphragm paralysis associated with an ISB used for shoulder surgery.⁸

Although ISB remains the current standard for regional anesthesia during shoulder surgery, research has continued to investigate the possibilities of other anesthetic techniques that may prove to be safer or more efficacious in patient recovery. As an alternative, Okoroha et al¹¹ recently published findings that local infiltration of liposomal bupivacaine provides similar overall pain relief compared with ISB, without increases in complications or length of stay.

Conclusion

ISBs are proven to play a beneficial role as an adjunct for shoulder operations but are not devoid of risk. Multiple reports have associated phrenic nerve injuries to ISB resulting in persistent hemidiaphragmatic paralysis.^{5,7,8,13,14} Preoperative risk assessments, having a sound knowledge of regional anatomy, using nerve stimulators, and preferably, direct visualization during ISB with the use of US, can decrease the risk of adverse outcomes and allow for improved placement of anesthetic medication.^{1,3,6} Although rare, recognizing this condition is critical because patients may benefit from pulmonary rehabilitation, surgical decompression, and nerve grafting.⁸ In addition, further research into alternative anesthetic techniques, such as the use of local infiltration of liposomal bupivacaine, holds promise for decreasing morbidity and improving patient outcomes.¹¹

Disclaimer

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