Abstract: Interscalene brachial plexus block (ISBPB) offers good analgesia for painful surgical procedures on the shoulder. We here describe two cases of long term phrenic palsy following ISBPB that occurred in our practice in a relative short time period and both clearly illustrate the devastating impact of this complication for the patient. We will discuss the benefit of ISBPB in the context of the incidence and significant disability of hemi diaphragm paresis. Anesthesiologists must be aware of this complication and carefully weigh the advantages of ISBPB against the risks of this complication. When ISBPB is considered, the fact that the incidence of prolonged phrenic nerve palsy may be higher than previously expected should be taken into account carefully. A reevaluation on the indication and patient selection of ISBPB may even be warranted.

Key words: Regional anesthesia; interscalene brachial plexus block; complication; phrenic nerve palsy.

INTRODUCTION

Interscalene brachial plexus block (ISBPB) offers good analgesia for shoulder surgery. Although peripheral nerve blocks are considered safe techniques, ISBPB has a high incidence of ipsilateral phrenic palsy causing paralysis of the hemidiaphragm (1). While often transient, prolonged and persistent phrenic nerve paralysis has been described (2). Furthermore, recent literature suggests that the incidence of this potential severe complication is higher than previously indicated. We here describe two cases of long term phrenic palsy following ISBPB that occurred in our practice in a relative short time period and both clearly illustrate the devastating impact of this complication. We will discuss the benefit of ISBPB in the context of the incidence and significant disability of hemidiaphragm paresis.

Patient 1

A 66 year-old female (174 cm, 98 kg) was scheduled for arthroscopic rotator cuff repair on the left shoulder. Her medical history included chronic obstructive pulmonary disease Gold 3, hypercholesterolemia, smoking and hysterectomy. The interscalene brachial plexus was localized using an IU22 ultrasound scanner equipped with an L12-5 linear transducer (Philips Medical systems, Best, the Netherlands). After raising a skin wheal with lidocaine 2%, ISBPB was performed with a 5 cm 22 gauge needle (SonoPlex Stim cannula, Pajunk) in the posteriocaudal medial direction, under ultrasound visualisation combined with nerve stimulation (Stimuplex HNS12, Braun Medical inc. Bethlehem USA). Muscle contractions were absent below 30 mA and contractions of the diaphragm were not observed during the procedure. Twenty millilitre of ropivacaine 0.75% was injected lateral from the plexus at the level of C6 and perineural spread around all nerve roots with local anesthetic was confirmed with ultrasound. After 30 minutes a sensory blockade in the shoulder was observed without adverse effects.

The patient also received general anesthesia and after surgery the patient was pain free and discharged home the same day. 3 months after recovery she was referred to a pulmonologist because of orthopnoea and dyspnoea on exertion. Chest x-ray showed an elevated hemidiaphragm on the left side, suggesting paralysis, which was confirmed by paradoxical diaphragmatic motion on fluoroscopy. As pulmonologic evaluation revealed no other cause, the hemidiaphragmatic paralysis was related to the interscalene blockade. Supportive treatment consisted of oxygen therapy and adaptations in her home and social live. It was decided to continue...
conservative treatment for at least one year to await spontaneous recovery.

Patient 2

A 58 years old male, (180 cm, 103 kg) was scheduled for elective arthroscopic rotator cuff repair of the right shoulder. His medical history included non-insulin dependent diabetes and a spondylodese at C6-7. No neurologic deficits were identified during preoperative screening. ISBPB was uneventfully performed using the same methodology and equipment as described in case 1. 18 ml of ropivacaine 0.75% was injected and ten minutes after injection of the ropivacaine, the patient complained about dyspnoea, which was relieved in the upright position. After exclusion of causes needing treatment, such as pneumothorax, it was decided to continue with surgery. Under general anesthesia, arthroscopic rotator cuff repair was performed uneventful.

In the postanesthesia care unit the patient was painfree and experienced only mild dyspnoea, which was acceptable in the upright position. The patient was discharged home at the end of the same day.

The symptoms of dyspnoea continued to 10 days after surgery and 13 days after surgery the patient developed a pneumonia that was treated by conservative treatment for one year to await spontaneous recovery.

Discussion

Interscalene brachial plexus block (ISBPB) is frequently employed for analgesia after surgical procedures on the shoulder. Shoulder operations often require high doses of opioids for postoperative pain treatment (3). Despite the development of less invasive surgical techniques, one third of the patients report severe pain on the first post-operative day following arthroscopic shoulder surgery (4). To this end, the use of local-regional anesthesia techniques, such as single shot interscalene blockade, have been widely adopted as first choice analgesia for surgical procedures on the shoulder (5).

In this paper we described two patients with prolonged hemidiaphragmatic paresis following ISBPB. The incidence of transient diaphragm paralysis following a successful ISBPB is almost 100% but a prolonged duration is rare (1). However, two recent studies reported an incidence of prolonged hemidiaphragmatic paresis following ISBPB of respectively 0.048 and 1% (6, 7).

The mechanism for prolonged hemidiaphragmatic paresis is unclear, but may relate to causes known to inflict nerve injury, such as transection, piercing, stretching and compression. Direct nerve injury by surgery or the needle itself seems unlikely in the present cases, as the risk for phrenic nerve injury during rotator cuff repair is negligible (8) and during the ISBPB contractions of the diaphragm were not observed. Furthermore, in plane ultrasound guidance is mostly used for ISBPB. In this approach needle insertion is shifted from the groove between the anterior and middle scalene muscle, as described by Winnie (9), to a more distal/lateral puncture side. Two directions of puncture are used: medial to lateral with increased risk for of both vascular and phrenic nerve lesions and lateral to medial with risk of damage to the long thoracic and dorsal scapular nerve (10). To avoid the complication risks of both the needle directions the superior trunk approach may be a solution. This procedure targets the C5 and C6 components of the brachial plexus more distally after they unite into the superior trunk but before the suprascapular nerve branches off (11). In both our case the lateral to medial needle direction was used.

The phrenic nerve however is vulnerable to compression due to its anatomic position between the anterior scalene muscle and prevertebral fascia (12). It is suggested that compressive forces of the injected local anesthetic trigger the formation of peri- and intraneural scar tissue in response to mechanical, vascular and/or ionic alterations in the phrenic nerve. The role of nerve entrapment and compression neuropathy in the pathophysiology of prolonged phrenic nerve palsy after ISBPB is supported by recent case series that demonstrate the efficacy of surgical decompression with or without nerve grafting in 69% of the cases. Whether anatomical variations increase the risk for phrenic nerve entrapment is unclear, but in two cases the authors observed an anomalous relocation of the phrenic nerve and in two other patients diaphragm...
paralysis was caused by adhesions between the phrenic nerve and a tortuous dilated transverse cervical artery (the red cross syndrome) (13). In the latter patients, surgical decompression combined with ligation of the vessel restored diaphragmatic function.

As nerve compression seems important in the development of phrenic nerve entrapment after ISBPB the employed volume of local anesthetic is part of discussion (14). Reduction of volume from 20 to 10 ml does not result in reduction of transient phrenic pareses, while the occurrence of phrenic nerve palsy was importantly reduced with volumes as low as 5 ml (15). In our two cases, a relative large volume of local anesthetic (respectively 20 and 18 ml) was injected. The pathogenesis of nerve injury may also involve the neurotoxic effect of local anesthetics and the ischemic effects of adjuvants such as epinephrine. Although the concentration of 7.5 mg/ml ropivacaine is widely used for brachial plexus blockade, some studies recommend the use of lower concentrations (16).

Ultrasound improves efficacy of peripheral nerve block compared with nerve stimulation techniques (17). Whether ultrasound can decrease the number of complications such as nerve injury or systemic local anesthetic toxicity is still subject of debate. Prolonged phrenic nerve palsy has been reported after ultrasound guided ISBPB (6). Ultrasound guidance facilitates the use of lower volume and the combination of ultrasound and low volume seems to be beneficial in prevention of transient hemi-diaphragm paresis (18).

In addition to the technique related risk factors, patient related risk factors have been identified as well. Any interruption from the small blood vessels in the nerve sheath surrounding the axons can lead to endoneurial oedema and hence to paralysis/paresis (12). In patients who have a mild, subclinical phrenic Neuropathy from previous neck surgery or trauma, or in those with systemic peripheral neuropathy (diabetes) the phrenic nerve may be more vulnerable.

One of our patients suffered from had a history of diabetes and previous cervical spine disease that may have increased the risk for prolonged phrenic neuropathy with hemidiaphragmatic paresis as a result (12).

Also overweighted and obese patients are more vulnerable due to the metabolic syndrome that includes early undiagnosed neuropathy. The transient diaphragm paresis will be more obvious in obese patient because of the decreased respiratory reserves (12).

The patient described in our first case suffered from moderate COPD that might be considered as a contraindication for ISBPB. Diaphragm paralysis after ISBPB may evolve asymptomatic in case of sufficient pulmonary reserve. However, if pulmonary function is compromised, diaphragmatic paralysis can cause respiratory disturbance that may have a substantial impact on quality of life. Both our patients suffer severe respiratory disability after ISBPB.

Although not stated with numbers we believe that the development in ultrasound guided techniques has led to an increase in local and regional techniques. The relatively high incidence of prolonged hemidiaphragmatic paralysis combined with the severity of disability is concerning. For comparison, the incidence of permanent neurologic complications following neuraxial analgesia is estimated at 85:1,710,000 (19). We therefore recommend that the benefits of ISBPB with regard to postoperative analgesia should be weighed against the risks of potential devastating complications. This may especially be important in patients with impaired pulmonary function and pre-existing neurologic deficits. Therefore, in these patients, alternatives for the ISBPB, such as the suprascapular nerve block and/or an axillary nerve block should be considered. The suprascapular nerve block alone reduces postoperative shoulder pain and opiate consumption (3, 20), but is less effective compared to ISBPB (21). Combined with an axillary nerve block however, complete analgesia of the shoulder can often be achieved (20, 22, 23, 24).

Finally, it was decided in both patients of the present case report to wait at least one year, as previous studies on the effect of unilateral phrenic section and lung function indicate that lung function normalizes in 12 months (25, 26). Current evidence indicates that after this period surgical treatment often offers better results than nonsurgical treatment (27). In case of residual nerve activity on nerve conduction and electromyographic studies, phrenic nerve surgery that includes phrenic nerve decompression, nerve grafting or nerve transfer, can be considered. If no residual nerve activity is present, diaphragmatic plication surgery can be considered.

Conclusion

Prolonged hemidiaphragmatic paresis is a serious complication following interscalene brachial plexus blockade. Anesthesiologists must be aware
of this complication and carefully weigh the advantages of ISPBPs against the risks of this complication. When ISPBPs is considered, the fact that the incidence of prolonged phrenic nerve palsy may be higher than previously expected should be taken into account carefully. Moreover, considering the latter a reevaluation on the indication and patient selection of ISPBPs may even be warranted and alternative nerve blocks should be considered.

References

7. Pakal S. R., Beckman J. D., Lyman S., Zayas V. M., Cervical spine disease is a risk factor for persistent phrenic nerve paresis following interscalene nerve block, Regional Anesthesia and Pain Medicine, 38, 239-242, 2013.