of nitrous oxide may have led to different oxygen regimens in some patients. This, however, would most probably not have affected our conclusions. If some patients in "high F_{IO_2}" groups had actually received a "not so high F_{IO_2}," and some patients in "normal F_{IO_2}" groups had received a "higher than normal F_{IO_2}," this would have weakened the beneficial effects of high oxygen fraction. Thus, our conclusions could have indeed been too conservative and the true beneficial effects of high F_{IO_2} would actually be even more pronounced. Drs. Hedenstierna and Edmark are also skeptical about our conclusions on postoperative atelectasis. We fully agree with their view that the occurrence of perioperative atelectasis is of multifactorial etiology. Yet, the question is not so much whether intraoperative atelectases occur in surgical patients, as there is general agreement that this happens, but whether or not intraoperative high oxygen regimens increase the risk of clinically relevant postoperative atelectasis. To date, there is no evidence from randomized controlled trials to suggest that this is the case.

Dr. Belda and colleagues suggest an interesting method to better allow for potential sources of heterogeneity in meta-analyses. Although they agree that high F_{IO_2} should be considered to reduce the risk of surgical site infection, and that this intervention may provide protection throughout a large range of surgeries, they argue that additional trials, with standardized outcome measures and including high-risk patients, will be needed to ensure adequate power and to guarantee wide applicability of these results. We agree that further large trials including patients at high risk of surgical site infection may be warranted. However, it should be highlighted that trials in patients who are not receiving prophylactic antibiotics are probably not ethically acceptable anymore. Thus, the challenge will be to confirm the anti-infective efficacy of high oxygen regimens in surgical patients who are receiving prophylactic antibiotics concomitantly and in whom the baseline risk of infection will be, accordingly, low.

Finally, Dr. Meyhoff and colleagues nicely highlight strengths and weaknesses of meta-analyses. We would like to reassure Dr. Meyhoff that we did not have, as they seem to suggest, any bias in favor, or against high inspired oxygen. One may, or may not, agree with our methodological choices, yet our process was overt; every step of the critical appraisal of included and excluded studies, as well as the rationale behind all quantitative analyses, were transparent, clearly described, and reproducible. Also, we have pointed out for the first time that almost all patients in these trials had received prophylactic antibiotics. This is a serious methodological issue that needs to be addressed when analyzing the anti-infective efficacy of high oxygen regimens and it is surprizing that this problem has not been pointed out in previous similar analyses. We are looking forward to the conclusions of the preannounced Cochrane review on the same subject, and we do hope that Dr Meyhoff and colleagues will take advantage of the methodological considerations depicted in our publication to further our understanding on the clinical relevance of high inspired oxygen fraction during surgery.

Competing Interests

The authors declare no competing interests.

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Permanent Diaphragm Paralysis after Shoulder Rotator Cuff Repair: Interscalene Block Is Not the Only Factor

To the Editor:

We read with interest the case series "Surgical Treatment of Permanent Diaphragm Paralysis after Interscalene Nerve Block for Shoulder Surgery."[1] We agree with the conclusion made by authors that the current practice of regional anesthetic blocks should continue to focus on technical accuracy, including use of ultrasound guidance. We would like to point out that in 3 of the 14 patients listed in the authors' report, no guidance was used (either ultrasound or nerve stimulation) for performing the interscalene brachial plexus block (ISB). This is not a currently accepted standard of practice.[2] Apart from the factors mentioned in the report, there are several other etiological factors that one needs to consider with regard to phrenic nerve injury in this subset of patients. These may include use of superficial cervical plexus block along with ISB, presence of local or systemic sepsis, intraoperative stretch during arthroscopic surgery, effect of excessive irrigating fluid near the nerves, and occult preexisting neurapraxia. The information on these factors is not available from the case series. We also

notice that in 6 of the 14 patients, epinephrine-containing solutions were used for the block which may worsen the ischemic injury to the nerve.[3] Eight patients had continuous catheter that might have been a factor for triggering fibrosis around the nervous tissue.[4] Some centers use superficial cervical plexus block in addition to ISB for shoulder analgesia, this could contribute to direct injury to phrenic nerve as the phrenic nerve lies in close proximity to superficial cervical plexus.[5] In the case series, the patients with preexisting neuropathy had poorer outcome after corrective surgery which may highlight the safety aspect of ISB in this subset of patients. Another important factor predisposing to chronic phrenic nerve palsy is the presence of cervical spine disease, which although not mentioned in the report needs to be considered while performing ISB.[6] The most interesting finding in the case series is that all the patients referred with hemidiaphragm paralysis were male patients with higher body mass index who had undergone shoulder rotator cuff repair. The authors point out the patients with higher body mass index might have coexisting conditions predisposing to phrenic nerve paresis. They did not state that the patients with higher body mass index are more likely to be symptomatic due to an already burdened respiratory system and are therefore more likely to need referral for surgical treatment. So the presented cases may actually underestimate the prevalence of hemidiaphragm paralysis after shoulder surgery. In obese patients with short neck, repeated attempts are common with potential for nerve injury and irritation as well as contamination of the site with bacteria as well as the antiseptic solution.[7,8] There are no data presented as to the evidence of low-grade or full-blown catheter/block site infection in the postblock period in this subset of patients.

Patient positioning during arthroscopic shoulder surgery has been associated with various nerve injuries.[9] The lateral decubitus position has been associated with the potential for peripheral neurapraxia, brachial plexopathy, and direct nerve injury. The beach-chair position has been associated with cervical neurapraxia and pneumothorax. The rotator cuff injuries themselves can result in clinical or subclinical reflex sympathetic dystrophy,[10] which can have a component of phrenic nerve palsy. In fact, ISB may benefit this subset of patients.[11] Because data on preexisting phrenic nerve paresis, chronic pain issues, or measures to evaluate the same in the patients mentioned in the study are lacking, directly blaming these cases to ISB without definitive evidence may be inappropriate. It would be informative to the readers to mention that multifactorial etiology is more likely the cause of such an event especially in susceptible population, therefore caution should be used while preforming ISB for such patients and the recommendation for performing the block should be made on case-to-case basis.

We believe that the anesthesiologists should focus on strategies to provide phrenic nerve sparing ISB to avoid phrenic nerve involvement altogether. This includes performing ISB at lower level (C7 level), injecting local anesthetic posterior to plexus, using lower volumes and concentrations of local anesthetic.[12–14] It will be useful to know the volumes and doses of local anesthetic used in this subset of patients. Some local anesthetic agents are considered more myotoxic than others and their toxicity is proportional to the duration of exposure and the dose.[15] It would be advisable to use the least myotoxic local anesthetic agent for ISB and consider use of neuroprotective adjuvants.[16]

We would like to clarify to the readers that the case series presented does not establish a cause and effect relationship between ISB and permanent diaphragmatic paralysis. As suggested in the editorial[17] accompanying the case series, until such studies are available, it would be reasonable to continue offering ISB to patients undergoing shoulder surgery. We must congratulate the authors for having elegantly shown us that even delayed surgical release is beneficial in improving phrenic nerve function and thus may reduce disability caused by hemidiaphragmatic paralysis.

Competing Interests

The authors declare no competing interests.

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Interscalene Brachial Plexus Blocks and Phrenic Nerve Palsy

To the Editor:

We were interested to read Kaufman *et al.*'s[1] article on the surgical treatment of 14 cases of permanent diaphragm paralysis after shoulder surgery, but dismayed to read the editorial that accompanied it,[2] in which it was stated that the diaphragmatic paralysis was "clearly due to phrenic nerve damage after interscalene brachial plexus block." This assertion is open to question and is not supported by the data presented by Kaufman *et al.*[1]

There is a remarkable similarity between this assertion and that made for many years that the ulnar neuropathy suffered by some patients after surgery was clearly due to errors in ontable positioning that resulted in external nerve compression. The finding that there was a preponderance of obese male patients suffering ulnar nerve neuropathy led to a view that although direct compression may be a factor, other factors such as ulnar nerve stretching and inadequate blood supply to the ulnar nerve were more likely to be of significance.[2–8] All Kaufman's patients were male; all were overweight or obese; their mean age was 58 yr. Phrenic nerve lesions may be associated with degenerative cervical spine disease, trauma, and compression,[9–13] and it is possible that these factors played a significant part in the cases described by Kaufman. Rotator cuff repairs are now commonly performed arthroscopically—these are often lengthy procedures performed with the patient in the lateral position and with traction applied to the arm, and in which swelling in the neck commonly results from saline infused under pressure into the joint for prolonged periods. It may well be that the combination of obesity, degenerative spine disease, nerve traction, and nerve compression were therefore significant factors in these cases.

We agree that the performance of an interscalene block may have been a factor (all 14 had blocks), but details of the approach used would have been informative, as a standard lateral, that is, modified Winnie, technique or out-of-plane ultrasound-guided approach brings the needle tip closer to the phrenic nerve compared with the currently popular in-plane ultrasound-guided needle approach through the middle scalene muscle. It may well be that the use of a Tuohy needle and a catheter (the majority of cases) were also factors. However, it is incorrect to assume that the block was the only factor—statistical association does not imply causation. Furthermore, if local anesthetic-induced myotoxicity is implicated as an important cause of nerve damage, why do we not see it more regularly around the many other small nerves that we regularly block?

Hogan's conclusion that the cause of the phrenic nerve damage is local anesthetic injection is premature, and his suggestion that interscalene block be replaced for these procedures by "peripheral application of local anesthetic" is not supported by the data presented. As ever, we need to know more before we reach conclusions.

Competing Interests

The authors declare no competing interests.

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