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Awake spinal fusion

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ABSTRACT

'Awake spinal fusion' is a novel approach to spine surgery that combines modern anaesthetic and surgical technique resulting in improved patient satisfaction and overall outcomes. Along with techniques of regional anaesthesia, minimally invasive or endoscopic surgical techniques are used to minimize surgical dissection and blood loss. Although, it is a relatively new concept with limited supporting evidence till date, it may prove to be highly effective in reducing post-operative hospital stays, in-hospital complications and cost of surgery while at the same time expediting recovery and rehabilitation. The current review focuses on techniques, advantages, limitations and the available evidence on awake spinal fusion.

1. Introduction

The rate of spinal fusion surgeries is on a steady rise in the last few decades owing to longer life span and consequently increased prevalence of degenerative spinal pathologies.[1,2] This rise in the number of fusion surgeries has also mirrored major improvements in surgical techniques, anaesthetic procedures, and rehabilitation protocols, all aimed at limiting the post-operative hospital stay, expedited rehabilitation, and early return to work. Surgical technology has evolved from open techniques to minimally invasive and endoscopic procedures, thus limiting tissue dissection, blood loss, and operative time during fusion procedures. At the same time, there have been tremendous improvements in local and regional anaesthetic techniques for spine surgical procedures. The recently introduced Enhanced Recovery After Surgery (ERAS) protocol has been implemented in the field of spine surgery and has helped improve outcomes, decrease length of stay, and improve overall satisfaction.[3] Apart from the clinical and technical benefits, ERAS has helped improve the cost effectiveness of spine surgery thus reducing the financial burden on patients and hospital administration. 'Awake spinal fusion' is a novel approach to spine surgery that combines multimodal anaesthetic techniques with minimally invasive spine surgery that has resulted in faster mobilization, decreased length of stay, and overall improved patient satisfaction and outcomes.[4] Although all these technical advancements have been recommended under various different clinical settings separately, the combination makes this approach highly efficient.

2. Technique

2.1. Anaesthesia

(Table 1) Awake spinal fusion employs local or regional anaesthesia during surgery. The use of spinal anaesthesia for lumbar disc herniation was first described by Ditzler et al., in 1959.[5] Since then, a number of studies have compared the risks and benefits of regional anaesthesia with the more prevalent general anaesthesia for treating lower thoracic and lumbar spine disorders.[6–9] The role of long acting local anaesthesia for dorsal and lumbar spinal procedures has also been explored by various investigators.[10,11] However, the use of regional anaesthesia techniques for interbody fusion procedures is largely unexplored. The apprehension for the use of spinal anaesthesia stems from the unpredictable duration of surgery while dealing with degenerative pathology. Surgeries lasting longer than the estimated operative duration may require intra-operative conversion to general anaesthesia by repositioning the patient supine. Similarly, failure of regional anaesthesia during surgery may also preclude conversion to general anaesthesia. Additionally, the use of sedation in the prone position for long surgeries may lead to respiratory compromise. Nevertheless,

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careful patient selection, minimally invasive and endoscopic surgical techniques, along with the development of improved anaesthetic drugs such as liposomal bupivacaine has encouraged the use of local and regional anaesthesia techniques in spinal fusion procedures, thus making 'Awake spinal fusion' possible.[4,12,13] Kolcun et al. analysed clinical outcomes in 100 patients undergoing endoscopic transforaminal lumbar interbody fusion procedure without general anaesthesia. They used intra-operative sedation and liposomal bupivacaine in para-spinal musculature for anaesthesia and reported significant improvements in patient reported outcomes, lesser post-operative hospital duration, and 100% fusion at one-year follow-up.[12] Due to the risk of respiratory compromise, a surgical cut-off time of 120 min was set by Wang et al. It is an important drawback of their technique as this operative duration may be insufficient for completion of a surgical procedure especially if it involves more than a single level. Chan et al. in a technical note described another technique for 'awake spinal fusion' that was principally similar but technically different from the above described technique. They used minimally invasive TLIF technique with a combination of locally infiltrated liposomal bupivacaine and spinal anaesthesia in order to improve pain outcomes and allow surgery to extend beyond 120 min.[13] However larger sample size and longer follow-up is needed for validation of the technical and clinical efficacy of the technique.

2.2. Surgical

Minimally invasive surgical technique as opposed to open surgical technique for spinal fusion has been found to have lesser surgical duration, blood loss and post-operative stay along with better patient reported outcomes.[13] Open surgical technique entails wide exposure with subperiosteal stripping and more blood loss, thus making it unsuitable under local or regional anaesthesia. Therefore, minimally invasive or endoscopic technique is the preferred technique and can be performed under conscious sedation during 'Awake spinal fusion'. Wang et al. in their technique have used endoscopic transforaminal lumbar interbody fusion as described earlier.[4] An important limitation of their technique lies in the patient selection. The technique mainly relies on indirect decompression by increasing the intervertebral height and therefore, limits the usage in central, bilateral or severe stenosis. Moreover, obligatory use of expandable cages and osteobiologics adds up to the cost and further limits the usage of this technique. Chan et al. on the other hand have described the use of minimally invasive surgical technique with a one-inch incision bilaterally.[13] This is possible because Chan et al. supplemented the locally infiltrated liposomal bupivacaine with a spinal anaesthesia one level above or below the operated segment. Minimally invasive techniques take care of central, bilateral or severe stenosis. Additionally, a minimally invasive technique is preferable over endoscopic technique for revision surgery.

Table 1
Peri-operative protocol for 'awake spinal fusion'.

Preop medication	Acetaminophen 1000 mg; gabapentin 600 mg (hold for CKD w/ GFR <60, age >70 yrs)
Intra-operative management	
Pre-operative management	
Pre-op medication	Acetaminophen 1000 mg; gabapentin 600 mg (hold for CKD w/GFR <60, age >70 yrs)
Intraoperative management	
Pre-procedure sedation	Midazolam per anaesthesiologist (ideally <2 mg); fentanyl per anaesthesiologist (ideally <100 μg)
Lumbar spinal	15 mg of isobaric bupivacaine (3 cc 0.5% bupivacaine, preservative free); 10–25 μg fentanyl; injected 1 space
Sedation	Propofol titrated to Ramsay Sedation Scale score of 2–3 (25–50 μg/kg/min); ketamine 2 μg/kg/min; limit opiates;
Alternate options	dexmedetomidine, fentanyl/midazolam
Blood pressure support	Consider fluid bolus; phenylephrine gtt vs ephedrine to maintain MAP 65 mm Hg or 80% baseline
Nausea prophylaxis	Dexamethasone 4 mg IV × 1 (hold for patients w/ diabetes mellitus)
Surgical infiltration given as a TLIP block)	Infiltration of 10 ml of liposomal bupivacaine (20 ml of 1.3% liposomal bupivacaine diluted w/20 ml of normal saline to total vol of 40 ml) to each incision/ percutaneous screw tract
For inadequate analgesia after 2 h	Re-inject 1 ml of 0.5% bupivacaine w/24-gauge pencil-tip spinal needle on surgical field
Postop management	
Pain control	Avoid PCA; acetaminophen 1000 mg q4h ATC; gabapentin 300 mg PO TID; oxycodone 5 mg PO q3h PRN
Voiding	Check bladder in PACU, consider single shot catheterization when necessary
Mobilization	Physical therapy day of surgery
Discharge	w/in 24 h

3. Advantages

Lesser post-operative hospital stays Although comparative evidence in a prospective randomized study is lacking, Wang et al. reported a mean post-operative stay of 1.4 ± 1.3 nights which was significantly less than their previously published data.[4] Use of local and regional anaesthesia results in less post-operative delirium, haemodynamic disturbances and also less opioid use in post-operative period. From the surgical stand-point minimally invasive techniques involve lesser tissue dissection, blood loss and surgical duration and thus, early rehabilitation. The above mentioned factors together shorten the post-operative hospital stay.

Cost -effectiveness There has been a growing interest in reducing the cost of spine procedures as the extravagant costs associated with spinal procedures takes a financial and mental toll on the patients and institutions. A number of researchers have therefore analysed the feasibility and clinical outcomes of 'outpatient' spinal fusion procedure in an attempt to reduce costs associated with the post-operative hospital stay and in-hospital complications. Chin et al. studied the feasibility of open TLIF procedures on an outpatient basis and reported significant improvement in patient reported outcomes. Of note, patients in this series were carefully selected for living close to a hospital, availability and willingness of family to assist the patient with postoperative care, low BMI, low cardiac risk, and a favourable American Society of Anaesthesiologists rating and a special emphasis was given on analgesics on discharge.[14] Eckman et al., in another study concluded that old age predisposed to longer hospitalization. They were able to discharge 73% of the patients undergoing single or double level MIS TLIF. Of note, they performed only unilateral soft tissue exposure with rods and screws only at the side of decompression. Nevertheless, unilateral decompression limits the spectrum of indications for which the procedure can be safely and adequately used.[15] 'Awake spinal fusion' is known to expedite the recovery time and reduce the post-operative hospital stay. However, longer follow-up studies with cost-effectiveness analysis is warranted.

Patient reported outcomes Kolcun et al.[12] have reported significant improvement in patient reported outcomes with no pseudoarthrosis or implant failure. They concluded 'awake spinal fusion' to be a durable and successful procedure with meaningful improvement in patient's functional status in long-term follow-up following this procedure. Authors have also reported better post-

operative analgesia, shorter recovery time, lesser costs and improved peri-operative morbidity and mortality.[16]

Neurological monitoring Awake spinal fusion offers a distinct advantage over the conventional GA techniques to the operating surgeon as the patient is able to provide live feedback if there is any contact or tension with any neural structure. This advantage is particularly more conspicuous when liposomal bupivacaine is infiltrated alone without spinal anaesthesia.

4. Limitations

Despite many notable advantages, the procedure is not free of its own set of limitations and drawbacks. A good surgical technique is crucial to the success of this procedure. 'Awake spinal fusion' employs minimally invasive or endoscopic techniques. Both techniques are different from the conventional open technique with respect to instrumentation and narrow corridors for interbody fusion. These surgical procedures therefore have a steep learning curve.

A number of anaesthetists are reluctant to position the patient prone without a protected airway, especially for longer durations. Therefore, the importance of close airway monitoring throughout the procedure cannot be understated. Morbid obesity, high BMI, pre-existing COPD, and obstructive sleep apnea may be recognized as a few relative contraindications to the procedure due to pre-existing poor respiratory reserve in these conditions. Additionally, local and regional modes of anaesthesia have their duration of action. These factors limit the operative time and therefore restrict the indications to one- or two-level lumbar canal stenosis or spondylolisthesis.

Patients with pre-existing anxiety may be unable to tolerate the orthopaedic operation theatre due to unpleasant loud sounds produced by the instruments. This may result in hemodynamic disturbances and post-operative confusion or depression in these patients. Administration of propofol and ketamine infusion has shown to be beneficial in such circumstances. Additionally, music therapy has shown tremendous benefits in reducing post-operative anxiety and enhance recovery in patients undergoing spine surgery.[17,18] It can be an effective alternative for anxious patients undergoing spine surgery under conscious sedation, although its definitive role is yet to be explored.

Lastly, absolute contraindications for spinal anaesthesia in general (bleeding disorders, site infections, low blood pressure) hold true for 'awake spinal fusion' as well. Apart from these, spine specific contraindications include severe spinal stenosis, failed back syndrome, or radiological demonstration of arachnoiditis.[9]

5. Evidence

Awake spinal fusion is a recent advancement in the field of spine surgery. Before 2016, the role of local and regional anaesthesia for spinal fusion was relatively un.explored. Wang et al. analysed the clinical outcomes of 10 patients who underwent endoscopic TLIF under locally infiltrated liposomal bupivacaine.[4] It was a preliminary study and the authors reported significantly improved patient reported outcomes, no cases of non-union or pseudoarthrosis and a post-operative hospital stay of 1.4 ± 1.3 days. The authors concluded that endoscopic fusion under conscious sedation is a feasible alternative to traditional methods with good results.[4] The same group of authors in 2019 reported the results of 100 patients with a follow up of 1 year with minor refinements in their surgical technique. They concluded the procedure to be safe and efficacious with less morbidity than open procedures.[12] Chan et al. in the same year published a technical note describing their technique of 'awake spinal fusion' using MIS technique. They concluded the successful use of spinal anaesthesia along with liposomal bupivacaine for providing operative analgesia for MIS procedure.[13]

6. Conclusion

'Awake spinal fusion' is a promising new technique and may prove to be highly effective in reducing post-operative hospital stay, in-hospital complications and cost of surgery while at the same time expediting recovery and rehabilitation. It may be implemented in sync with the ERAS protocol as both the protocols are complimentary to each other. Despite its various advantages, well structured, randomized, prospective and multi-centre trials with large sample size and long follow-up is needed to establish safety, efficacy and cost-effectiveness of this technique.

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Declaration of competing interest

Alok D Sharan – consultant for paradigm spine. The remaining authors declare no conflict of interest.

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