Regional Anaesthetic Techniques and Their Implications During the COVID Pandemic

Raafay Mehmood1 · Ainsley John McGuire2 · Zainab Mansoor1 · Adam Benjamin Fink1 · Gabriel Atanasov1

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Abstract
The current pandemic has highlighted the need to protect both patients and medical staff. The increased use of regional anaesthesia as a primary anaesthetic modality for operations and other invasive procedures has limited the number of aerosol-generating procedures performed during general anaesthesia. Its use is further characterized by decreases in postoperative pain and length of hospitalization. This article provides an overview of regional anaesthetic techniques (peripheral nerve locks, epidural and spinal anaesthesia) and their uses during the COVID pandemic.

Keywords Regional anaesthesia · Peripheral nerve block · Spinal anaesthesia · Epidural anaesthesia

Introduction
The COVID-19 pandemic is a significant burden on healthcare systems globally. As anaesthesiologists are front line workers in surgical management, they are often exposed to patients’ respiratory secretions, placing themselves at further risk of viral transmission. It becomes important to minimize the utilization of aerosol-generating procedures (AGPs) often performed during general anaesthesia (GA) [1]. These include bag-mask ventilation, bronchoscopy, bronchoalveolar lavage, endotracheal intubation, extubation and open airway suctioning [2]. Regional anaesthesia (RA) can be used to avoid airway manipulation, and it has become a common modality in surgical procedures during the pandemic [3].

RA involves the reversible numbing of a specific body part in order to prevent any sensation of pain [4]. It can further be divided into peripheral nerve blocks and neuraxial anaesthesia (spinal and epidural anaesthesia). Although GA can be used in a variety of surgeries, the use of RA provides further benefits in addition to reduced airway management including the following: decreased postoperative nausea; decreased stay in the post-anaesthesia care unit (PACU); lower risk of respiratory and gastrointestinal complications; and fewer opioid related side effects (pruritis and respiratory depression) [5]. Furthermore, RA is commonly used to reduce acute postoperative pain, which is reported by more than 80% of patients undergoing surgery [6]. Treatment of postoperative pain results in improved clinical outcomes, as it has been investigated that poor acute pain control can lead to chronic devastating pain [7]. This is commonly seen in orthopaedic surgery, which is highly associated with severe postoperative pain, where a suitable pain management protocol to improve the patient’s range of movement is vital for successful rehabilitation and early return to daily activities [8, 9]. The purpose of this manuscript is to review the literature and evaluate data pertaining to the advantages and disadvantages of RA techniques.

Peripheral Nerve Blocks
A peripheral nerve block (PNB) involves the use of a local anaesthetic injection in the proximity of a nerve or peripheral nerve bundle, which results in the inhibition of the excitatory action potential, responsible for transmitting a nociceptive stimulus along the various nerve fibres towards the central nervous system [10]. They can be used independently as the only anaesthetic, or used as a supplement to GA. There are different types of nerve blocks such as specific nerve blocks, brachial plexus blocks and paravertebral blocks as well as a single injection and continuous...
nerve blocks. They are commonly used in surgeries involving the following: the extremities, elderly patients [11] and in certain major orthopaedic surgeries such as shoulder and hip replacement [10]. Additionally, PNBs are often used to modulate the pain response postoperatively with the use of single shot or continuous nerve blocks [12–15]. Their use is contraindicated in cases of allergy to the local anaesthetic agent, in the presence of certain illnesses such as epilepsy, porphyria (lidocaine), chronic lung disease, severe liver disease, peripheral neuropathies, haemostasis and coagulation disorders, as well as patient refusal and infection at the puncture site [16].

PNBs are carried out in 3 steps: preparation, administration and recovery. The first step can be considered the most crucial, as it requires a thorough patient history and preoperative assessment regarding the PNB technique and anaesthetic risk. During this step, patient consent is received, confirmation that the patient is in a fasting state as well as confirmation that the patient does not have any contraindications [10]. Following this step, the PNB is administered in a process that requires patient positioning, anatomical landmark identification and puncture [17]. During the puncture, a motor response is evoked by a nerve stimulator and/or ultrasound to localize the nerve, and after this, the injection of anaesthetic can begin. This consists of a slow injection of anaesthetic with the subsequent loss of the motor response. Once the anaesthesia has been administered, there is an inhibition of proprioceptive transmission, resulting in the regional block of nerve transmission from the target nerve. It becomes extremely important to monitor the patient for signs of both cardiotoxicity and neurotoxicity. The last stage begins upon completion of the procedure and involves the patient transfer to the PACU. There, the patient is continuously monitored until they are deemed to have no complications from anaesthesia and surgery until their subsequent discharge [10].

PNBs can be implemented in a wide variety of cases, for example, treatment for primary headache disorders, where the greater and lesser occipital nerves are commonly used, although sometimes several branches of the trigeminal nerve can also be used [18]. Continuous PNBs are routinely used in the peri- and postoperative period; however, their use in the treatment of chronic pain in cancer, complex regional pain syndrome and phantom limb pain has also been well-documented [19]. PNBs, in addition to their many different indications, offer a range of benefits which include decrease of baseline pain, reduction of any additional analgesic requirements and reduced postoperative inflammation and can be utilized in the treatment of sleep disorders. However, the safety and success of PNBs are dependent on the correct technique for delivery of the local anaesthetic as well as the correct dose. Failure to do so can result in potential, although rare, complications such as systemic toxicity, infection, nerve damage and bleeding [20, 21].

### Epidural Anaesthesia

Epidural anaesthesia (EA), is not only a subtype of neuraxial anaesthesia, but is also a type of regional anaesthesia. It involves the insertion of a hollow needle, alongside a small and flexible catheter, into the epidural space—which contains fat, blood vessels, lymphatics, and the spinal nerves exiting the spinal cord [22]. Furthermore, it can be performed in the cervical, lumbar or thoracic regions of the spine as well as the sacral hiatus [23]. Opioids, anaesthetic and analgesic agents can be delivered through the catheter to achieve different purposes. EA can be provided alone or in conjunction with general anaesthesia for postoperative pain modulation. In terms of the distribution of an epidural neural block, significant factors include the mass of local anaesthetic, the site of injection and patient variables in the determination of the extent of the sensory, sympathetic, and motor neural blockade [24]. Height, weight and BMI do not have a clinically significant impact on the spread of epidural block. However, age does have an effect as a given dose of local anaesthetic agent will spread farther in older patients when compared to younger patients [25].

EA is commonly used in surgical settings to reduce perioperative stress and thereby improve postoperative outcomes; meta-studies have indicated a significant reduction in perioperative cardiac morbidity, pulmonary infections, pulmonary embolism, acute renal failure and blood loss [26]. EA is used frequently in labour pain relief, surgeries of the abdominal, intra-thorax or lower extremities and used to modulate pain postoperatively [25]. In comparison to spinal anaesthesia (SA), EA requires greater dosages of local anaesthetic and takes longer to implement. However, once the catheter is in place, anaesthetic agents can be repeatedly administered, and their effects can be prolonged to match the surgery. The contraindications of EA are similar to those of SA due to both being types of neuraxial anaesthesia. Their use is contraindicated in cases such as patient refusal, compromised sterility of medical instruments, coagulopathies, infection at the site of injection, increased intracranial pressure, severe aortic stenosis, severe mitral stenosis, an allergy to local anaesthetics and severe uncorrected anaemia. Relative contraindications of EA include sepsis, severe spinal deformities, an uncooperative patient, demyelinating lesions, pre-existing neurological defects and stenotic valvular heart lesions [27].

EA is carried out in a series of consecutive steps. The first step is patient preparation, entailing the assembly of equipment needed, positioning of the patient (which can be either sitting or lateral dependant on the procedure), current clinical situation (hip fractures, emergency C-section)
dural space, intrathecally, blocking all motor and sensory
where local anaesthetic is injected 2–3 mm beyond the epine-
Spinal Anaesthesia

and a more extensive block [33].

labouring women, they are associated with better analgesia
allowing for a greater distribution of the anaesthetic agent. In
As needed. Depending on the clinical scenario, catheters with
will be encountered, a transition occurs when the needle

A spinal block consists of a single injection with last-
ing effects up to 3 h after administration, hence making
it unsuitable for lengthy or unpredictable operations [25].
Additionally, the motor nerve block generated is sufficient
to use when preforming major surgeries such as hip or knee
replacements. However, continuous SA with the use of a

catheter can be used to provide a prolonged duration of the
spinal block, but it requires a dural puncture with a large
gauge needle. These needles are associated with high inci-
dences of headaches [36]. Yet, the smaller the needle, the
lower the risk for post-dural puncture headache. Addition-
ally, continuous spinal catheters have the potential to be mis-
taken as an epidural catheter, which can lead to dangerous
levels of the anaesthetic in the subarachnoid space, if a large
epidural dose is administered. If unrecognized, this can lead
to respiratory and cardiac arrest [37]. This is often the rea-
son for high block in labouring women during an attempted
epidural [38, 39].

SA provides an alternative to general anaesthesia for
several emergent situations such as emergency caesarean
sections, appendectomies and many elective surgeries, espe-
cially during this pandemic [40]. In 2003, an SA technique
was developed to address the need for SA in emergency
obstetrics, known as rapid sequence SA. This may now be
indicated, as most anaesthetic personnel are already wearing
the required personal protective equipment (PPE) regardless
of COVID positivity [41]. This technique addresses the time
and preparation required to perform classical SA, reducing
the requirements to a pair of sterile gloves, and is performed
using a single puncture without palpating anatomical land-
marks [42]. A second puncture is utilized if necessary,
before immediately transitioning to general anaesthesia in
case of failure. A retrospective study carried out in Wuhan
(the epicentre of the pandemic in early 2020) [43] found
that only 2.7% of anaesthesiologists who encountered PCR
positive patients while preforming SA then developed sub-
sequent COVID infections, providing that they were wear-
ing level 3 PPE. This highlights the safety in minimizing
aerosol-generating procedures and using techniques such as
SA instead of GA, where the case permits.

It has been hypothesized for some time now that SA may
produce better patient outcomes in comparison to the use of

Spinal Anaesthesia

Spinal anaesthesia is a subtype of neuraxial anaesthesia,
where local anaesthetic is injected 2–3 mm beyond the epi-
dural space, intrathecally, blocking all motor and sensory
function below the upper level of the block [34]. This ini-
tially blocks small unmyelinated sympathetic fibres, fol-
lowed by the blockage of both myelinated sensory and motor
fibres. Although there are no absolute indications for SA, its
use is dependent on patient, surgeon and anaesthesiologists’
preferences. It is, however, commonly indicated for surgeries
of the lower abdomen, perineal and lower extremities [35].
It is almost exclusively done in the lumbar region, below
the termination of the spinal cord. It can be used for upper
abdominal surgeries, but the impact on breathing at that
level calls for the use of GA.

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and the patient and provider. Patients with a BMI under 25
reported being more comfortable in the lateral position,
whereas patients with a BMI greater than 30 reported being
more comfortable sitting [28]. Following this step, anatomical
landmarks are palpated (such as the spinous processes
thus aiding in identifying the midline), and puncture can
commence. Before puncture can occur, an approach must
be decided either midline or paramedian. LEA can be per-
formed with either; however, TEA is performed more easily
using the paramedian approach. This is due to the thoracic
spine having a lesser degree of flexibility compared to the
lumbar spine and the steeper slope of the thoracic spinous
processes. Epidural needles usually have a curved tip for
guidance into the epidural space; in comparison to spinal
needles, they are typically larger. This feature improves the
tactile feel as the needle passes through the ligamentum
flavum and enters into the epidural space.

After the puncture, identification of the epidural space
can be done either through the hanging drop or loss of resist-
ance technique. The hanging drop technique relies on nega-
tive air pressure within the epidural space. On the hub of
the needle, a drop of saline is placed. Upon entry into the
epidural space, the drop will then be pulled into the needle
[29]. This method is more reliable for TEA than LEA. *The
loss of resistance technique is universally used: if the tip
of the needle is within the ligamentum flavum resistance
will be encountered, a transition occurs when the needle
tip enters the epidural space, as a loss of resistance is per-
ceived [30]. For this method, air or saline can be used in the
loss of resistance syringe. There is discussion as to which
is more advantageous, although a review conducted in 2014
determined no benefits of saline versus air in terms of locat-
ing the epidural space [31]. However, another review high-
lighted that the use of saline provides analgesic superiority
as well as decreasing morbidity, while also reporting fewer
occurrences of complications such as incomplete analgesia,
pneumocephalus, nerve root compression, subcutaneous
emphysema and venous air embolism [32]. After identifica-
tion of the epidural space, the catheter can be inserted into
the epidural space, and the needle can be removed. Place-
ment of a catheter allows for EA to be provided for as long
as needed. Depending on the clinical scenario, catheters with
a single orifice or multi-orifice can be used, with the latter
allowing for a greater distribution of the anaesthetic agent. In
labouring women, they are associated with better analgesia
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a GA for a given surgical procedure. A meta-analysis performed in 2018 found that patients who received SA prior to total hip arthroplasties required shorter hospitalizations post-operation and reported significantly lower levels of nausea in comparison to patients who underwent GA [44]. Conversely, a randomized control trial from the same year comparing the outcomes of patients who underwent foot and ankle surgery found that patients who received GA were discharged earlier than those who received SA, while there were no differences regarding reported nausea, opioid use, headaches or back pain [45]. Additionally, a 2018 study comparing the perioperative and postoperative outcomes of patients who underwent laparoscopic appendectomies found that those who had the procedure performed under SA suffered less surgical field pain and had a longer postoperative pain free period, while also reporting less postoperative nausea and vomiting [46].

**Benefits Over General Anaesthesia**

RA carries a risk profile for possible complications that can be variable depending on the clinical setting and purpose for which it is applied. This makes any sort of definitive answer on its overall safety impossible at this time, given the lack of studies extensively examining all the diverse forms these procedures can take, and the even more diverse populations they are performed on [47]. Additionally, research that examines the rates of complications and overall outcomes associated with RA alone versus GA alone is not yet fully developed. The uncertainty this creates in making comparisons between RA and GA is compounded by the fact that they are often more commonly indicated for different kinds of surgery [48]. However, there is a growing body of evidence suggesting that the use of RA, in combination with GA or alone, decreases the rates of some complications and improves some postoperative outcomes compared to procedures employing only general anaesthesia [49].

One major grouping of complications where the benefits of RA are supported in a number of surgical settings are those involving the cardiovascular system, including, but not limited to, conditions such as deep venous thrombosis, pulmonary embolism and cardiac events. The deep sympathetic blockade provided by the use of neuraxial anaesthesia in intrathoracic and intra-abdominal surgeries results in improved lower extremity blood flow, lowered incidence of hypercoagulability and a reduced cardiac effort [50]. Furthermore, the use of postoperative epidural anaesthesia offers superior analgesia, continuous low-dose local anaesthetic effects as well as avoidance of systemic opioids. This in turn results in improved bowel mobility; improved coughing and breathing; and earlier ambulation, further reducing the risk of complications related to circulation and coagulation in the extremities [50, 51].

RA causes fewer incidences of postoperative side effects increasing the length of hospital stay. Postoperative nausea and vomiting can lead to not only longer post-anesthesia care unit stays but also delayed day surgery unit discharge and unplanned hospital admission. The mechanism for the reduction of this side effect with RA is likely to be multifactorial, yet probably related to the avoidance of systemic opioids and other sedatives that are known to disrupt bowel function [50, 52]. Reduced quality of sleep is another side effect related to the length of stay. Shorter duration of sleep, fragmented sleep patterns and reduced REM sleep have been associated with increased nociception. This can impact subsequent sleep and enhanced recovery programs. Furthermore, a later rebound in REM sleep has been associated with myocardial infarction, stroke and hemodynamic instability. The use of neuraxial anaesthesia intraoperatively, as well as in postoperative pain management, has been associated with improved sleep outcomes post-surgery, including a decrease in obstructive sleep apnoea, and likely benefits related to the reduced use of systemic opioids and sedatives [50, 53]. The severity of acute pain in the postoperative period has also been associated with increased duration of hospitalization, as well as being a factor in the likelihood of chronic postoperative pain. Epidural analgesia (regardless of the agent used, the type of surgery or the method of pain assessment) has been shown to provide superior analgesia to parenteral opioids [54].

RA also shows benefits in terms of reducing pulmonary side effects and postoperative respiratory function, with virtually no side effects in healthy people when administered correctly, and positive benefits for risk of complications in patients with pre-existing conditions like COPD and asthma [50, 55]. The mechanism for these benefits is largely to do with avoidance of the relatively numerous respiratory side effects stemming from general anaesthesia’s effects on consciousness; mode of ventilation; posture during the intraoperative period; as well as the actions of the anaesthetic agents and drugs used during anaesthesia on respiratory smooth muscles and secretions [56, 57].

**Implications During the COVID Pandemic**

During the pandemic, organisations such as The American Society of Regional Anesthesia and Pain Medicine and European Society of Regional Anaesthesia and Pain Therapy have highly encouraged the preferential use of regional anaesthesia, whenever possible, to minimize AGPs [40]. It has also become essential to pre-plan when performing RA, as the anaesthesiologist must be prepared for a failed block and conversion to GA, which increases the risk of
COVID transmission. The advantages RA holds in minimizing respiratory transmission disappear in the case of a COVID positive patient undergoing unplanned conversion to GA. Therefore, it is adamant that the anaesthetist plans accordingly to whether the whole operation can be carried out under RA; otherwise, it may be beneficial to start with GA rather than preparing for low-probability RA. Likewise, GA will be preferred in critically unwell intubated patients.

Severe COVID disease has the propensity to cause thrombocytopenia, which is a common contraindication for RA [58]. Anaesthesiologists screen both COVID positive and negative patients during a thorough pre-operative evaluation to deem their fitness for RA. In COVID positive patients, a review of a full blood count, percent saturation of haemoglobin with oxygen (SpO2 > 93%) and a suitable international normalised ratio (< 1.5) is required at minimum [59]. Additionally, a COVID infection can lead to a reduced respiratory reserve, which can be problematic for patients undergoing shoulder surgery, since the brachial plexus and interscalene block frequently cause phrenic nerve palsy [60]. Anaesthetic management of these patients requires limiting both the dose and volume of the local anaesthetic or alternatively performing suprascapular and axillary blocks to avoid any disturbance of the phrenic nerve.

As previously mentioned, the use of RA causes fewer pulmonary side effects compared to GA. A reduction in respiratory side effects and increased opportunity to forgo mechanical ventilation would likely contribute to a reduced risk of viral transmission associated with invasive respiratory intervention, shorter postoperative hospitalization and reduced use of respiratory support equipment urgently required in hospitals with large numbers of patients suffering the severe respiratory symptoms associated with COVID-19 [56, 61]. However, RA techniques are commonly carried out with intraoperative sedatives, which can also cause some respiratory depression [40]. In COVID positive patients, sedatives are avoided or used minimally.

RA’s role in reducing postoperative side effects and resultant hospital stay is especially significant in the present settings of the COVID pandemic, where reducing the exposure of patients and hospital staff to viral transmission is significant [56]. This also increases resources such as acute care beds, ventilators, advanced monitoring equipment and trained personnel that could be allocated to patients with severe illnesses.

The global pandemic has highlighted RA’s ability to preserve postoperative immunological function, via the attenuation of the stress response and the associated effect on cellular and humoral immunity [62]. This may prove crucial when operating on a patient who may have COVID-19, diagnosed or undiagnosed, or who may be inadvertently exposed to it following surgery as the volatile gases used in GA are known to lower postoperative immunity [63]. Many routine operations such as orthopaedic emergencies, caesarean sections, ectopic pregnancies, strangulated hernias, appendectomies and urological operations are currently being performed under RA [3]. Furthermore, many cancer surgeries such as from simple to complex mastectomies and sentinel lymph node biopsies are also performed under RA.

**Conclusion**

The era of COVID-19 has changed innumerable aspects of the context in which medicine is practiced, introducing new considerations and shifting the relative importance of core priorities in the field of anaesthesiology no less than any other. This not only presents significant challenges to practitioners and researchers that must be overcome, but also provides an impetus for innovation. The increased emphasis on avoidance of viral transmission brings shortening hospital stays, as well as reducing respiratory and immunological impacts to the forefront of considerations to be made when determining optimal anaesthetic regimes for various surgical settings. Given the relative advantages of RA in these regards, we believe that the altered context of the COVID-19 pandemic creates both an imperative and an opportunity to devote more resources to the development and refinement of this subset of anaesthetic techniques.

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