Ultrasound guided interscalene block: Pro/Con

A. Triunfo1, D. Galante1, M. Di Bari2, R. Caramia2, I. Manlio1, R. Leone1, M. Melchionda1, A. Gallicchio2

1University Department of Anesthesia and Intensive Care, University Hospital Ospedali Riuniti of Foggia, Italy
2Department of Anesthesia and Intensive Care, Hospital Dario Camberlingo, Francavilla Fontana (Brindisi), Italy

Corresponding author: A. Triunfo, University Department of Anesthesia and Intensive Care, University Hospital Ospedali Riuniti of Foggia, Viale L. Pinto, 71122 Foggia, Italy, Email: atriunfo@libero.it

Key points
Ultrasound blocks have changed regional anesthesia in adult and pediatric patients during the last years. This ability to directly image the process has resulted in some fairly predictable advantages of ultrasound use, which explain its ever-increasing popularity. These advantages include a higher block success rate when compared to nerve stimulation guidance, fewer needle passes with possibly less trauma, and a greater degree of sensory blockade. Anyway, it’s also necessary to look at the disadvantages of this technique. This article examines the advantages and disadvantages of the ultrasound guided interscalene block.

General consideration
The ability to visualize anatomy in real time at the bedside while performing peripheral nerve block (PNB) has dramatically changed many practitioners’ perceptions of regional anesthesia. While knowledge of anatomy remains a cornerstone of regional anesthesia, practitioners may now image anatomy in real time, as well as plan the needle path, avoiding vulnerable structures and ensuring local anesthetic delivery close to the nerve. Furthermore, the needle tip may be kept in view at all times as it is advanced, and local anesthetic spread modified as necessary to ensure appropriate perineural spread.

This ability to directly image the process has resulted in some fairly predictable advantages of ultrasound use, which explain its ever-increasing popularity. These advantages include a higher block success rate when compared to nerve stimulation guidance, fewer needle passes with possibly less trauma, and a greater degree of sensory blockade. Other improvements include a more rapid block onset, more rapid block conduct, and a longer analgesic duration. Ultrasound guidance allows multiple injections around the brachial plexus. Ability to inject multiple aliquots of local anesthetic also allow for the reduction in the volume of local anesthetic required to accomplish the block. Repetition of the block in case of inadequate anesthesia is also possible, a management option that is unpredictable without ultrasound guidance. These advantages have also translated into greater ease and success for peripheral catheter insertion. Finally, the risk of major vessel and nerve puncture during nerve block performance is reduced.

Ultrasound anatomy
The brachial plexus at the interscalene level is seen lateral to the carotid artery, between the anterior and middle scalene muscles. Prevertebral fascia, superficial cervical plexus and sternocleidomastoid muscle are seen superficial to the plexus. The transducer is moved in the superior-inferior direction until two or more of the
brachial plexus trunks are seen in the space between the scalene muscles. Depending on the depth of field selected and the level at which the scanning is performed, first rib and/or apex of the lung may be seen. The brachial plexus is typically visualized at a depth of 1 to 3 cm. (Figures 1, 2, 3, 4, 5)

**Fig. 1, 2**
The brachial plexus at the interscalene level

Fig. 3, 4, 5: Lateral axial ultrasound neck image at the C7 level. (1) Posterior tubercle of the C7 transverse process, (2) rudimentary anterior tubercle of the C7 transverse process, (3) C7 root, (4) middle scalene muscle, (5) anterior scalene muscle, (6) longus colli muscle, (7) sternocleidomastoid muscle, (8) vertebral artery, (9) carotid artery, (10) brachial plexus (C5-C6 derivatives)

**Indications**
Interscalene block can be used for surgeries on the shoulder, lateral clavicle, acromioclavicular joint and proximal humerus.

**Contraindications**
Absolute contraindications to interscalene blockade are patient refusal and severe local infection. A successful interscalene block also usually results in blockade of the ipsilateral phrenic nerve and thus ipsilateral diaphragmatic paresis. It is important therefore never to block both sides at the same time. Caution should be exercised in the following circumstances and in general they constitute relative contraindications for an interscalene block:

- Contralateral phrenic palsy
- Contralateral pneumothorax
- Contralateral pneumectomy
- Severe COPD

Ultrasound guided block may be judiciously performed in coagulopathic patients as the vascular anatomy can be identified and avoided.

**Distribution of blockade**
The interscalene approach to brachial plexus blockade results in anesthesia of the shoulder and upper arm. Inferior trunk for more distal anesthesia can also be blocked by additional, selective injection, deeper in the plexus. This is accomplished either by controlled needle redirection inferiorly or by additional scanning to visualize the inferior trunk and another needle insertion and targeted injection.

**Equipment**
Equipment needed includes the following devices:

- Ultrasound machine with linear transducer (8–14 MHz), sterile sleeve and gel
- Standard nerve block tray
• One 20-mL syringe containing local anesthetic
• 5-cm, 22-18 gauge short-bevel insulated stimulating needle
• Peripheral nerve stimulator
• Sterile gloves

**Landmarks and patient positioning during the procedure**

Any position that allows comfortable placement of the ultrasound transducer and needle advancement is appropriate. The block is typically performed with the patient in supine, semi sitting, or semi lateral decubitus position, with the patient’s head facing away from the side to be blocked \(^{(1,8)}\). The latter position may prove ergonomically more convenient, especially during an in-plane approach from the lateral side, in which the needle is entering the skin at the posterolateral aspect of the neck. A slight elevation of the head of the bed is often more comfortable for the patient, and it allows for better drainage and less prominence of the neck veins. Adherence to strict anatomic landmarks is of lesser importance for the ultrasound-guided interscalene block than it is the case for the surface anatomy-based techniques. Regardless, knowledge of the underlying anatomy and the position of the brachial plexus is important to facilitate recognition of the ultrasound anatomy. The goal is to place the needle in the tissue space between the anterior and middle scalene muscles and inject local anesthetic until the spread around the brachial plexus is documented by ultrasound. The volume of the local anesthetic and number of needle insertions are determined during the procedure and depend on the adequacy of the observed spread of the local anesthetic (Figures 6, 7).

**Technique**

**Medial to lateral approach** with the patient in the proper position, the skin is disinfected and the transducer is positioned in the transverse plane to identify the carotid artery. Once the artery is identified, the transducer is moved slightly laterally across the neck. The goal is to identify the scalene muscles and the brachial plexus that is sandwiched between the anterior and middle scalene muscles (Figure 8).
**Distal to proximal or ‘Traceback’ approach** when the visualization of the brachial plexus between the scalene muscles proves difficult, the transducer is lowered to the supraclavicular fossa. At this position, the brachial plexus is identified lateral and superficial to the subclavian artery. From here, the brachial plexus is traced cranially to the desired level (Figures 9, 10).

**In-plane approach** the needle is brought in the same plane as the probe so that the whole length of the needle can be visualised. The needle is visualised more easily when it is inserted at a shallow angle to the skin so that greater numbers of ultrasound waves are reflected back to the probe leading to a brighter image. This may mean that the point of skin entry is some distance away from the edge of the probe (Figures 11, 12).

**Out-of-plane approach** the needle is inserted cranial to the probe similar to techniques for internal jugular cannulation. The needle may be seen as a bright dot on the screen as it crosses the ultrasound beam. It may initially be difficult to be sure which part of the needle you are seeing as the “dot” may represent a cross-section of the shaft and not the needle tip. By tilting the probe, the tip is identified as the point where further tilting leads to the bright dot no longer being visualised on-screen. The movement of the surrounding tissues in response to rapid small movements of the needle may also aid its identification. This method is preferred by some only for catheter insertion (Figures 13, 14).
As the needle passes through the prevertebral fascia, a certain "give" is often appreciated. When nerve stimulation is used (0.5 mA, 0.1 msec), the entrance of the needle in the interscalene groove is often associated with a motor response of the shoulder, arm, or forearm as another confirmation of the proper needle placement. After a careful aspiration to rule out an intravascular needle placement, 1 to 2 mL of local anesthetic is injected to document the proper needle placement. Injection of several milliliters of local anesthetic often displaces the brachial plexus away from the needle. The presence of the motor response to nerve stimulation is useful but not necessary to elicit if the plexus, needle and local anesthetic spread are well-visualized. The neck is a very vascular area, and care must be exercised to avoid needle placement or injection into the vascular structures. Of particular importance is to avoid the vertebral artery, and branches of the thyrocervical trunk: inferior thyroid artery, suprascapular artery, and transverse cervical artery\(^{9-16}\) (Figures 15, 16).

Never inject against high resistance (>15 psi) because this may indicate a needle-nerve contact or an intrafascicular injection (see Figures 17, 18).
Pro and con of multiple injections

Pro: may increase the speed of onset and success rate of the interscalene block; may allow for a reduction in the total volume and dose of local anesthetic required to accomplish block.

Con: may carry a higher risk of nerve injury because part of the plexus may be anesthetized by the time consecutive injections are made.

Occasionally during interscalene block with ultrasound guidance, “posterior” shoulder twitches will be elicited on stimulation of the presumed target nerve. This is most likely due to stimulation of the suprascapular nerve, which branches quite proximally from the plexus to innervate the supraspinatus and infraspinatus muscles. In an adult patient, 15 to 25 mL of local anesthetic is usually adequate for successful and rapid onset of blockade. Smaller volumes of local anesthetics can also be effective, however, their success rate in everyday clinical practice may be inferior to those reported in meticulously conducted clinical trials.

Side effects

The following are classified as side-effects rather than complications because they are likely to be present with any successful ISB and are temporary and resolve with resolution of the block.

- Ipsilateral hemidiaphragm paresis is common sequelae to an interscalene block due to the proximity of the phrenic nerve to the interscalene groove.
- Recurrent laryngeal nerve blockade may occur, leading to hoarseness and swallowing difficulty.
- Horner's syndrome often occurs due to the proximity of the sympathetic cervical chain. 20%-50% (Figure 19).

Complications

Neurological complications

- Neuropathy, Neurotoxicity. The overall incidence of long-term nerve injury ranges between 0.02% and 0.4% may be a consequence either of intra-neural injection or direct trauma to the nerve by the needle. However, nerve injury is much more frequently due to surgical trauma.
- Epidural or spinal injection is a described complication and should be suspected if sensory defect of the contra lateral upper limb occurs.
- Intravascular Injection: neurotoxicity and cardio toxicity. Local anesthetic injected directly into the vertebral or carotid artery, or even in the small cervical vessels or retrograde flow of local anesthetic via the subclavian artery, may proceed directly to the brain or heart.

Durrani and Winnie reported a case of “locked in syndrome” following a probable intra-arterial injection of local anesthetic following an interscalene block.

If in doubt, use the color/powerdoppler function on the ultrasound machine to aid differentiation of a vascular structure from a nerve (Figures 20, 21).
Truini et al. Ultrasound interscalene block

Respiratory complications
Pneumothorax.

Muscle Injury
Myonecrosis from local anesthetics at concentrations typically achieved at the site of injection is well proven and characteristic of all local anesthetics, with bupivacaine producing the most intense effect. Because damage is dose related, continuous local anesthetic administration may worsen injury.

Vascular Injury
The risk of hematoma immediately after brachial plexus techniques is small (0.001 to 0.02%)

Haemodynamic Complications

We can note a high incidence of vasovagal episodes associated with the use of interscalene block for shoulder surgery in the sitting position. The episode consists of sudden hypotension and/or bradycardia, frequently associated with symptoms of light-headedness or nausea and sometimes (rarely) asystolic cardiac arrest requiring resuscitation. These symptoms are due to an activation of the Bezold-Jarisch reflex. It has to be known by the anaesthesiologists so that progression from prodromal symptoms to cardiovascular collapse may be avoided

US Check complications
Respiratory complications: pulmonary US (pleura sliding for PNX and diaphragmatic movement on deep breaths and forceful sniffing)

Haemodinamic: heart US

Myonecrosis and hematoma: muscle and soft tissue US(17-23) (Figures 22, 23, 24, 25, 26, 27, 28).
Continuous ultrasound guided interscalene block

Indications for catheter:

- Continuous regional analgesia
- Acute pain therapy (pre/postoperative)
- Management of chronic pain (CRPS)
- Supportive adjunct to physiotherapy/exercise therapy
- Sympatholysis (for improving wound healing)
- Preventive analgesia (phantom pain prophylaxis)

The goal of the continuous interscalene block is similar to the non-ultrasound-based techniques: to place the catheter in the vicinity of the trunks of the brachial plexus between the scalene muscles. The procedure consists of three phases: needle placement, catheter advancement, and securing of the catheter. For the first two phases of the procedure, ultrasound can be used to assure accuracy. The needle is typically inserted in-plane from the lateral-to-medial direction and underneath the prevertebral fascia to enter the interscalene space, although other needle directions could be used.

Both stimulating and nonstimulating catheters can be used.

Proper placement of the needle can also be confirmed by obtaining a motor response of the deltoid muscle, arm, or forearm (0.5 mA, 0.1 msec) at which point 4 to 5 mL of local anesthetic can be injected. This small dose of local anesthetic serves to assure adequate distribution of the local anesthetic as well as to make the advancement of the catheter more comfortable to the patient. This first phase of the procedure does not significantly differ from the single-injection technique. The second phase of the procedure involves maintaining the needle in the proper position and inserting the catheter 2 to 3 cm into the interscalene space in the vicinity of the brachial plexus. Insertion of the catheter...
can be accomplished by a single operator or with a helper. Proper location of the catheter can be determined either by visualizing the course of the catheter or by an injection of the local anesthetic through the catheter. When this proves difficult, alternatively, a small amount of air (1 mL) can be injected to confirm the catheter tip location (Figures 29, 30, 31).

There is no agreement on what constitutes the ideal catheter securing system. The catheter is secured by either taping to the skin or tunnelling. However, the decision about which method to use could be based on the patient’s age, duration of the catheter therapy, and anatomy. Tunnelling could be preferred in older patients with obesity or mobile skin over the neck and when longer duration of catheter infusion is expected. Two main disadvantages of tunnelling are the risk of catheter dislodgment during the tunnelling and the potential for scar formation. Fortunately, a number of catheter-securing devices are available to help stabilize the catheter (Figure 32).

### Ultrasound guided interscalene block Pro/Con

**Table 1.**

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>See the neural targets (sometimes)</td>
<td>Learning curve?</td>
</tr>
<tr>
<td>See the vascular structures</td>
<td>Some difficulty to accurately identifying of structures (fat patient)</td>
</tr>
<tr>
<td>Anatomic variation</td>
<td>The advancing needle is not that easy to see in many cases</td>
</tr>
<tr>
<td>See the advancing needle in real time</td>
<td>More tissues penetrate by needle (in plane)</td>
</tr>
<tr>
<td>See the actual spread of local anesthetic solution following the injection (Power Doppler)</td>
<td>Not always disposable</td>
</tr>
<tr>
<td>Risk of major vessel and nerve puncture during nerve block performance is reduced</td>
<td>Equipment cost, size</td>
</tr>
<tr>
<td>Less pain to perform: no muscular twitch (when patient has a fracture) and less number of puncture</td>
<td></td>
</tr>
<tr>
<td>Can perform rescue blocks (impossible with PNS)</td>
<td></td>
</tr>
<tr>
<td>Can do postop. (impossible with PNS)</td>
<td></td>
</tr>
<tr>
<td>US allow to perform a best LA spread versus the caudal region plexus (ulnar nerve block)</td>
<td></td>
</tr>
<tr>
<td>Sovrascapular block (voluntary during in plane approach) (no pain during insertion of posterior port)</td>
<td></td>
</tr>
<tr>
<td>More rapid block conduct, onset time and time to surgery and a longer analgesic duration</td>
<td></td>
</tr>
<tr>
<td>Less expensive? Saving time!</td>
<td></td>
</tr>
<tr>
<td>Continuous block, we don’t need twitch, and we can see the catheter</td>
<td></td>
</tr>
<tr>
<td>Check complications: pulmonary US (pleura sliding for PNX and diaphragmatic movement on deep breaths and forcible sniffing) heart US, muscle and soft tissue US, color and power Doppler for vessels</td>
<td></td>
</tr>
<tr>
<td>Future: 3d 4d US, nerve navigator</td>
<td></td>
</tr>
<tr>
<td>Not to see what we are doing but to think about what we are doing</td>
<td></td>
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PNS-guided interscalene block Pro/Con

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
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<tbody>
<tr>
<td>Identify which nerve we are approaching by twitch</td>
<td>CAN’T SEE: the neural targets, the vascular structures, the advancing needle in real time, the spread of local anesthetic solution following the injection, variable anatomy</td>
</tr>
<tr>
<td>Identify if indeed it is a nerve</td>
<td>More painful with movement of injured extremities and more number of punctures</td>
</tr>
<tr>
<td>Decreases learning time (?)</td>
<td>Variability of threshold for motor responses: neuropathy, demyelinating condition</td>
</tr>
<tr>
<td>Less expensive (?)</td>
<td>More time to perform block, higher onset time</td>
</tr>
<tr>
<td>More disposable, small, simple equipment</td>
<td>We can’t see the “scooching” after large dose LA injection</td>
</tr>
<tr>
<td></td>
<td>Blind continuous block</td>
</tr>
<tr>
<td></td>
<td>Not allows Low dose block</td>
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Ultrasound and nerve stimulation: is the block best performed with both?

Ultrasound gives visual confirmation

Nerve stimulation gives functional confirmation

Only during learning time. Successively the studies show no advantage in US plus PNS for PNB. Multi-injection, ultrasound-guided nerve blockade is faster and better than single-injection nerve stimulator-guided nerve blockade.

Multi-injection, ultrasound-guided nerve blockade may be faster and better than multi-injection nerve stimulator-guided nerve blockade. Adding nerve stimulation to ultrasound guided blocks may be more hindrance than help.

Discussion

The ability to visualize anatomy in real time at the bedside while performing peripheral nerve block (PNB) has dramatically changed many practitioners’ perceptions of regional anesthesia. While knowledge of anatomy remains a cornerstone of regional anesthesia, practitioners may now image anatomy in real time, as well as plan the needle path, avoiding vulnerable structures and ensuring local anesthetic delivery close to the nerve. Furthermore, the needle tip may be kept in view at all times as it is advanced, and local anesthetic spread modified as necessary to ensure appropriate perineural spread. This ability to directly image the process has resulted in some fairly predictable advantages of ultrasound use, which explain its ever-increasing popularity. These advantages include a higher block success rate when compared to nerve stimulation guidance, fewer needle passes with possibly less trauma, and a greater degree of sensory blockade. Other improvements include a more rapid block onset, more rapid block conduct, and a longer analgesic duration. Ultrasound guidance allows multiple injections around the brachial plexus. Ability to inject multiple aliquots of local anesthetic also allow for the reduction in the volume of local anesthetic required to accomplish the block. Repetition of the block in case of inadequate anesthesia is also possible, a management option that is unpredictable without ultrasound guidance. These advantages have also translated into greater ease and success for peripheral catheter insertion. Finally, the risk of major vessel and nerve puncture during nerve block performance is reduced.

In the first years of ultrasound use for PNB guidance, there was considerable doubt regarding whether this imaging modality provided measurable practical benefit, or whether it was an expensive extravagance. The studies and meta-analyses have markedly strengthened the evidence in favour of ultrasound for PNB. Other reports have made it clear that instructing residents is facilitated by use of ultrasound – in our own academic practice we have seen the frequency of inadequate or partial interscalene block drop from 15% to just over 4%. From a rotation director’s perspective, the advent of ultrasound was a truly remarkable advance for resident instruction, while at the same time enhancing patient safety. Guidelines for regional anesthesia instruction now routinely incorporate ultrasonography.

Unfortunately, the impact of ultrasound imaging on patient safety has not been demonstrated as clearly as its practical advantages. With regard to nerve injury, several large databases and some randomized trials have
failed to show a difference between guidance techniques, in terms of significant nerve injury or more mild postoperative nerve dysfunction (i.e. numbness and tingling). This may be because the majority of such injuries are not block related, or because neural dysfunction, if block-related, is attributable to factors other than needle-tip trauma such as local anesthetic neurotoxicity. Given these issues and the very low frequency of serious nerve injury, it may not be possible to show a difference in postoperative neurologic outcomes with the use of ultrasound to guide needle placement and local anesthetic deposition.

Avoiding intraneural injection.

Modern ultrasound machines can easily detect intraneural injection, but they do not have the resolution to identify intrafascicular vs. extrafascicular needle placement. Current nerve stimulator technology has a very high positive predictive value. That is, if a motor response is present at stimulation thresholds of < 0.2 mA (without any dextrose injected prior to stimulation), intraneural needle placement is almost certain. However, the absence of a motor response at high stimulation thresholds (upwards of 1.0 mA), does not rule out an intraneural needle location. One explanation is that the needle may be adjacent sensory neurons but distant to motor neurons. Recently, injection pressure monitoring has been suggested as protecting against LA injection related nerve injury: low injection pressures ruling out harmful intrafascicular injection. However, this technology also has its limitations as other factors unrelated to intrafascicular injection may result in high injection resistance e.g needle/catheter orifice obstruction by fascia. Furthermore, recent evidence suggests that intrafascicular injection may not invariably be associated with high injection pressures. Impedance over 600Ω strongly suggest for intraneural injection. Implication: So what can the operator do to guard against intraneural and more importantly, intrafascicular LA injection? The only intervention that can eliminate intrafascicular (and probably also intraneural) injection is to use an 18G (or larger) Tuohy needle. The needle’s calibre is such that it is simply not possible to place inside a nerve fascicle, and with the exception of the sciatic nerve, its diameter and tip configuration virtually precludes it from being placed inside a nerve. Where possible, the needle should be inserted so it approaches the nerve along its long axis (rather than perpendicular), which will further protect against nerve impalement.

Ultrasound, nerve stimulation and injection pressure monitoring are all useful in providing additional operator reassurance regarding appropriate extraneural injection.

The influence of ultrasound upon the other major adverse outcome from PNB, local anesthetic systemic toxicity (LAST), has been more readily addressed in the literature. Two large databases provide evidence for a very low frequency of seizure or cardiac toxicity when ultrasound is used to guide nerve blocks. While prior estimates of LAST ranged from 1/1000 to 1/7000 when nerve stimulation was the primary method of guidance, Sites et al. recently reported the experience at Dartmouth, where in a six-year period, over 12,000 ultrasound-guided blocks resulted in only one episode of LAST (a seizure). A six-year experience at University of Pittsburgh Medical Center-South Side in some 6,000 nerve stimulator blocks, there were six seizures, while in the 9,000-plus blocks conducted with ultrasound guidance, there were no episodes of LAST. Temporally, there was a clear correlation between the use of ultrasound and reduced risk of seizures. Finally, the most compelling data regarding improved safety comes from a multi-center Australia-New Zealand database recently reported as an abstract at the 2012 American Society of Anaesthesiologists annual meeting. Barrington, et al. summarized their results with over 20,000 peripheral nerve blocks conducted with either ultrasound or nerve stimulator guidance. Both univariate and multivariate regression established ultrasound guidance as a factor which favourably influenced the occurrence of LAST, with an odds ratio between 0.18
and 0.25. The total dose of local anesthetic and dose per patient body weight were likewise correlated with toxicity risk.

Some reasons for ultrasound imaging favourably affecting LAST are obvious. There are fewer vascular needle punctures, primarily because vessels can be visualized. While this may only be a surrogate for intravascular injection, it probably plays a role. In addition, ultrasound has allowed a marked decrease in local anesthetic doses while still providing effective blocks, which inevitably impacts on safety. What is not so obvious, perhaps, is that for many blocks, use of the ultrasound transducer changes our trajectory of needle insertion: shallower, more oblique approaches are necessary to image the needle and to align the needle under the probe. Thus, we are less likely to plunge the needle deep beyond the nerve where sizable vessels may be inadvertently punctured and subjected to injection (for example, vertebral artery puncture during interscalene block).

In summary, even if studies are small and not uniform in design; results are not uniform and proving a safety benefit is difficult; ultrasound has clearly had a favourably influence upon the technical and practical aspects of PNB performance, and its popularity continues to grow.

Moreover US equipment will continue to get better, smaller, and cheaper; technical improvements such as 3D US or neuronavigator will make simpler the US approach; block techniques will be refined; outcomes and performance data will accumulate.

Finally we think the best aid of US PNB is not to see what we are doing but to let us think what we are doing (26-32).

Acknowledgements

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Recommended Bibliography


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