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Review article

Regional anaesthesia in ambulatory surgery

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Abstract

Regional anaesthesia provides many advantages and can be practised safely in ambulatory surgery. It provides better postoperative pain control, avoids many complications associated with general anaesthesia and shortens recovery time. However, extra time required, associated complications and acceptance of patients are the factors of concern in practising regional anaesthesia in an ambulatory setting. This review will discuss various regional anaesthesia techniques suitable for outpatients.

Keywords: Ambulatory surgery; Ambulatory anaesthesia; Regional anaesthesia

1. Overview

Given the changing patterns of health care delivery, considerable growth is occurring in ambulatory surgery worldwide. Regional anaesthesia has long been practiced in ambulatory surgery, but general anaesthesia is by far the commonest anaesthetic technique [1–3]. This article emphasizes the great potential for regional anaesthesia for outpatients, and the advantages and disadvantages for specific regional anaesthetic technique will be discussed.

2. Advantages and disadvantages

2.1. Advantages

Randomized studies comparing the morbidity of general versus regional anaesthesia are difficult to design and are frequently inconclusive. Some advantages of regional anaesthesia are discussed as follows (Table 1).

2.1.1. Avoidance of complications of general anaesthesia

Complications from general anaesthesia such as sore throat, nausea and vomiting, aspiration, airway trauma and muscle pain can be avoided or minimized. Although the risk of sore throat is minimized with the use of laryngeal mask airway for general anaesthesia, the incidence still ranges between 4 and 12% [4]. Nausea and vomiting is the commonest anaesthesia-related cause for unanticipated hospital admission following ambulatory surgery [2,5] whilst aspiration contributes 12% of hospital admissions in an ambulatory surgical centre [6]. With regional anaesthesia technique, the incidence of nausea and vomiting is significantly re-

Table 1
Advantages of regional anaesthesia compared to general anaesthesia

Avoid complications related to general anaesthesia (nausea and vomiting, airway trauma, aspiration pneumonia)
Smooth transition to postoperative pain control
Shorter recovery time
No loss of consciousness and 'control'

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duced [7–9] and the risk of aspiration and sore throat can be avoided.

2.1.2. Better postoperative pain control

Regional block, either alone or combined with general anaesthesia, facilitates a smooth transition to postoperative analgesia. It adds to the comfort and satisfaction of patients. In addition, the use of narcotics is reduced and thus the associated side effects can be minimized. When comparing different anaesthetic techniques for inguinal herniorrhaphies, those who had local infiltration or regional anaesthesia required less analgesia in the postoperative period [10]. Using three-in-one block for knee arthroscopy, postoperative pain control is better than general anaesthesia [11]. Similarly, suprascapular nerve block or femoral nerve block, when combined with general anaesthesia, have also been demonstrated to reduce postoperative pain following complicated arthroscopic surgery [12,13].

2.1.3. Faster recovery

Recovery from anaesthesia and duration of hospital stay can be reduced with regional anaesthesia. In two large-scale studies, regional anaesthesia was associated with shorter recovery time than general anaesthesia [1,2]. However, these studies were neither controlled nor randomized. Studies comparing recovery time of different anaesthetic techniques did show that recovery was faster with regional anaesthetic technique [7,11]. In a prospective, randomized study comparing different anaesthetic techniques in outpatient hand surgery, duration of stay in Post Anaesthesia Care Unit (PACU), time to ambulate and oral intake was much shorter with brachial plexus block compared with general anaesthesia [14].

2.1.4. No loss of consciousness and 'control'

Remaining conscious and feeling of 'in-control' are advantages offered by regional anaesthesia. Patients may remain wide awake intraoperatively, allowing the surgeons opportunity to demonstrate the disease process and the surgical repair. Morbid fear about general anaesthesia is not uncommon among patients receiving their first anaesthetic. In a comprehensive survey of 800 patients' attitude towards anaesthesia, the most common concern or fear expressed by patients was inability to emerge from anaesthetic [15]. Regional anaesthetic technique offers a welcome alternative.

2.2. Disadvantages

2.2.1. Time factor

Extra time is needed for a nerve block to be adequate for surgery. However, the delay caused by the increased anaesthetic time can be offset by the shortened recovery time of the patient [14,16].

To minimize the delay, the regional block can be performed in a separate induction room or a designated area in the PACU. Obviously, a skilled anaesthetist is required. Some authors suggest that ambulatory surgery should not be the place to learn regional blocks, especially for the junior resident [17,18]. However, this depends on the comfort level of the anaesthetist and the availability of the time resources. In our institution, we do not exclude the junior resident from learning regional blocks in the ambulatory surgery setting.

The onset time of the block can be shortened by proper choice of technique and drug or addition of adjuvant, e.g. bicarbonate to the local anaesthetics [19].

2.2.2. Acceptance factor

The majority of patients prefer general anaesthesia over regional anaesthesia if given the choice of anaesthetic [15,20]. The main reasons are that they preferred not to 'see or feel anything' or they believed 'spinal anaesthesia to be dangerous' [15]. In contrast, most practicing anaesthetists themselves prefer to receive regional to general anaesthesia for both emergency and elective peripheral surgery [21,22]. The difference in the preference of anaesthetic technique probably reflects the importance of knowledge on the influence of patients' attitude towards regional anaesthesia.

2.2.3. Nerve injury

The principle of regional anaesthesia is to deposit local anaesthetic to the vicinity of nerve plexus, nerve root or individual nerve to stop the transmission of nerve impulse. Nerve damage, albeit rare, is a potential complication in regional anaesthetic technique. Brachial plexus block via axillary approach is the commonest nerve block performed for the upper limb. Neurological complications ranged from 0–19% and were usually transient [23–28]. In a recent large series using transarterial technique in 996 patients, the risk of neurological complication is negligible [28].

Safety of intrathecal anaesthetic has been well established. Studies involving 20 000 patients receiving spinal anaesthesia showed that no major neurological sequela resulted [29,30]. However, the minor form of neurological complication transient radicular irritation (TRI) has aroused concern among those practicing anaesthetists recently [31,32]. Three prospective studies show that the incidence of TRI following the use of hyperbaric lidocaine ranged from 10–37% [33–35]. Various factors may contribute to the etiology of TRI but dose and concentration appeared to be the most important. With the use of dilute lidocaine solution (less than 1.5%), the risk of TRI may be minimized.

2.2.4. Associated complication of regional block

Backache is common after central neuroaxial blockade, ranging widely from 2–46% [8,36–39]. In the past, many believed that back pain occurred as frequently after general anaesthesia as after spinal anaesthesia [36,37]. Postoperative back pain appears to be related to the length of surgery and the position of the patient than the type of anaesthetic used. Recent studies found that the incidence of backache is higher following spinal/epidural than general anaesthesia [8,40]. Backache following the lumbar puncture is thought to result from direct needle trauma of ligamentous and periosteal structures.

Postdural puncture headache and urinary retention are infrequent but important complications following spinal anaesthesia and will be discussed in a later section.

3. Preparation and set-up

Options of regional anaesthetic technique should be suggested to the patients before arrival in the holding area where they are waiting anxiously for the surgery. This involves collaborative effort among the surgeons, nurses and the anaesthetists. It is very helpful if the option of regional anaesthesia is suggested to the patient in the surgeon's office. In the pre-admission clinic or pre-anaesthetic clinic, patients can be further screened and informed about the choice of regional techniques. This allows patients to think over the choice of anaesthetic and offers opportunities to clarify some of the concerns patients may have about regional anaesthesia. Information in the form of pamphlets or video cassette gives patients a better idea about the anticipated regional anaesthetic technique. If the regional anaesthetic technique requires the use of nerve stimulator or seeking of paresthesia, the patient should understand this to obtain maximal co-operation.

To minimize the time restraint, a designated area in which nerve block can take place is necessary. This can be a separate room beside the operation theater, the holding area or PACU. The area should be fully equipped with resuscitation equipment and monitors. A designated nurse can improve the efficiency of performing the regional anaesthesia. While the anaesthetist is still in the operating theater, the nurse can put monitors on the patient, start the intravenous access and explain the anticipated procedure.

Music is a very useful non-pharmacological sedative for patients receiving regional anaesthesia. Some institution has individual headsets in every operating theater and a control box to allow patients to set the volume and choose the type of music they desired. This helps the patients to relax and screen some of the unwanted noises inside the operating theater. Some institutions like ours offers patients a special goggle so that they can watch movies.

Table 2
Application of regional techniques to specific operation

Technique	Surgery
Central neural block (spinal/epidural/combined)	Lower abdominal surgery
	Laparoscopy (e.g. tubal ligation), hysteroscopy
	Perineal surgery (caudal or spinal)
	Lower extremity surgery
	Knee arthroscopic surgery
	Ankle open (e.g. fusion) or arthroscopic surgery
	Vascular procedure (e.g. varicose vein stripping)
Upper limb regional block	
IVRA[a], axillary block	Orthopedic or plastic surgery below elbow
Axillary, supraclavicular block	Surgery at elbow (e.g. transposition of ulna nerve)
Interscalene block	Shoulder surgery (open or arthroscopic surgery)
Lower limb regional block	
'3-in-1' Block	Knee arthroscopic surgery
Popliteal or ankle block, ?IVRA[a]	Bunion surgery, tarsal/metatarsal surgery, neuroma excision

[a] IVRA = intravenous regional anaesthesia.

4. Spinal anaesthesia

4.1. Advantages of spinal anaesthesia

Spinal anaesthesia provides an excellent and reliable anaesthetic technique for procedures of lower abdomen and extremity (Table 2). Its role in ambulatory surgery is still controversial. It is reliable, easy to perform, has a rapid onset of action, and provides good pain relief and muscle relaxation. Its ability to provide sacral anaesthesia makes it superior to epidural techniques [41]. In general, dose response is highly predictable and the small doses of local anaesthetic drug required for subarachnoid blockade eliminate the chance of systemic toxicity. Postoperative nausea and vomiting are less prevalent following spinal anaesthesia versus general anaesthesia [8,9].

Despite these advantages, there are two main concerns of using spinal anaesthesia in ambulatory setting: postdural puncture headache (PDPH) and urinary retention.

4.2. Postdural puncture headache

Postoperative headache is common even after general anaesthesia, ranging between 15 and 43% [8,42]. The incidence of true postdural puncture headache depends on various factors: age, sex, needle size, and design of needle bevel [43,44].

Since PDPH occurs only when patients assume upright position, one will suggest that it is more common in ambulatory settings. However, many studies has shown that the incidence of PDPH is not affected by the duration of bedrest [45–47].

Early experience of the use of spinal anaesthesia has been associated with a high incidence of PDPH. Flaaten noted a 37.2% incidence of PDPH in 51 young male outpatients given spinal anaesthesia through a 25G Quincke needle [48]. Those patients who developed headaches were off work for a significantly longer time than those who did not. Using small gauge needles in 658 ambulatory outpatients, Kang reported the incidence of PDPH was 9.6% and 1.5% for 26G and 27G respectively [49]. Only 12 of 31 (38.7%) patients in the 26G group and 1 of 5 (20%) in the 27G group required epidural blood patch. Failure rate with small needles is very low ($< 1\%$). Satisfaction and acceptance is higher in the 27G group. A total of 98.2% of patients in the 27G group wished to have spinal anaesthesia again in the future. With pencil-point needle (Sprotte), Pittoni achieved an incidence of PDPH 0.8% for 22G and 0% for 25G with very low failure rate (0.8%) [50]. The only patient in 22G group who had PDPH responded to conservative management without resorting to epidural blood patch. This patient underwent spinal anaesthesia 6 months later with the use of 25G Sprotte needle and no PDPH was recorded.

Where PDPH might be an acceptable complication for an inpatient who anticipates 3 to 4 days of hospitalization, this complication can be considered a serious setback for a young, healthy, active outpatient anticipating a rapid return to work or a resumption of other daily activities. Corbey reported an incidence of PDPH of 4.5 and 8% when 26G and 27G Quincke needle were used in outpatients under 45 years of age. Majority of them responded well to conservative treatment and none of them required epidural blood patch [51]. Hence, for younger patients who have a higher incidence of headache and who have an urgent need to return to full ambulatory function within 24 h after the surgical procedure, these patients are not the ideal candidates for spinal anaesthesia.

4.3. Urinary retention

Urinary retention is an uncommon complication following spinal anaesthesia. This adds to the patient's discomfort and may result in unanticipated admission for patients undergoing a simple procedure [50].

Urinary retention is due to complex effects on peripheral and central neurogenic mechanisms controlling the micturition reflex. This would include autonomic blockade, estimated to be three times longer than two segment regression [52]. Following spinal anaesthesia, autonomic function will have returned to baseline when motor function in the lower extremity, proprioception of the big toe, and sensory function in the perianal region have returned to normal [53].

Various factors may increase the risk of developing urinary retention following spinal or epidural anaesthesia: male gender, site of surgery, amount of intraoperative intravenous fluid and duration of blockade, the last one being the most important factor. A much higher incidence of urinary retention was reported with the use of longer-acting local anaesthetic than the short-acting one for either spinal or epidural anaesthesia [54,55]. A total of 25% of outpatients receiving spinal anaesthesia with heavy bupivacaine 0.5% requiring catheterization in the postoperative period to relieve urinary retention before discharge has been reported [39] and this can result in subsequent unanticipated admission [50].

Large amounts of perioperative intravenous administration may result in overdistention of bladder, but the correlation with urinary retention is unclear [56]. Urinary retention tended to occur more frequently in association with groin and perineal procedures [50,54]. Pain at the incision site associated with attempts to void may be a contributing factor.

Urinary retention almost always subsides with the complete recovery from anaesthesia and seldom necessitates bladder catheterization. Various methods are recommended to decrease this side effect: minimize use of a long-acting local anaesthetic, restriction of the infusion of fluids perioperatively, early mobilization, psychological encouragement, and delay of catheterization. However, if catheterization is indicated, patients may simply be catheterized once and discharged. Only in rare circumstances will a patient require an indwelling catheter overnight.

4.4. Modification of techniques recommended for ambulatory surgery

4.4.1. Choice of local anaesthetic

A short-acting local anaesthetic agent such as lidocaine is the drug of choice for spinal anaesthesia in the ambulatory setting. Longer-acting agents like bupivacaine and tetracaine should be avoided as they are associated not only with longer stay in recovery room but also higher incidence of urinary retention.

Lidocaine is commercially available in both hyperbaric (1.5 and 5%) and isobaric (2%) preparations (Table 3). The usual duration of action ranges from 30 to 90 min, shorter with the dilute concentration [57]. Lidocaine is ideal for lower abdominal surgery up to 60

Table 3
Local anaesthetics for spinal anaesthesia

Drug	Usual concentration (%)	Usual volume (ml)	Total dose (mg)	Baricity	Glucose concentration (%)	Usual duration (min)
Lidocaine	1.5, 5.0	1–2	30–100	Hyperbaric	7.5	30–90
Mepivacaine	4	1–2	40–80	Hyperbaric	9.0	30–90
Tetracaine	0.25–1.0	1–4	5–20	Hyperbaric Hypobaric Isobaric	5.0	75–150
Bupivacaine	0.5	3–4	15–20	Isobaric		75–150
	0.75	2–3	15–22.5	Hyperbaric	8.25	75–150

Adapted and modified from Strichartz, [57], with permission.

min and lower limb surgery requiring tourniquet up to 90 min. For surgery of longer duration, one can avoid using long-acting local anaesthetic by adding adjuvant. Fentanyl, a short-acting opioid, is the drug of choice. Addition of fentanyl 20 μg to plain lidocaine significantly increases the duration of anaesthesia to transcutaneous electrical stimulation, which is comparable to surgical stimulation [58], and tourniquet-induced pain without prolonging the motor block and time for voiding [59]. In contrast, addition of epinephrine 0.2 mg increases the duration of surgical anaesthesia and prolongs the time to void [60]. Hence, epinephrine should be avoided in an ambulatory setting as it results in an increase in time to spontaneous urination and discharge [61].

Recently, there is significant concern about the neurotoxicity of 5% hyperbaric lidocaine [31,32]. The incidence of transient radicular irritation following the use of hyperbaric 5% lidocaine ranged from 10–37% [33–35]. Although the symptoms usually resolve within 3 days, it can pose a significant problem for day surgery patients [62]. Even the manufacturer acknowledged the problem and recommended the dilution of 5% lidocaine with an equal volume of cerebrospinal fluid or preservative-free saline [32]. On the other hand, dilute concentrations of Lidocaine from 0.5 to 2%, either hypobaric or hyperbaric, have been shown to provide successful block for various surgery [63–66]. Recently, the minimum effective anaesthetic concentration has been defined and was shown to be 0.53 and 0.3% for a dose of 48 and 72 mg respectively [67]. Hence, it is prudent to use dilute lidocaine solution in ambulatory settings.

4.4.2. Choice of spinal needles

To minimize the risk of PDPH, the smallest spinal needle of pencil-point design should be used for ambulatory surgery [44]. With small Whitacre (26–27G) or Sprotte (24G) spinal needle, the incidence of PDPH can be reduced to 0.5% or lower [50,68]. Needle size less than 27G is not recommended as it increases the technical difficulty and thus associates with higher failure rate [69].

5. Epidural anaesthesia

Epidural anaesthesia is perhaps the most popular regional technique in the ambulatory setting for surgery of lower abdomen and lower extremity [17,70,71]. In a double-blind study, favorable discharge times for chloroprocaine or lidocaine epidural anaesthesia were found in outpatients [72]. When epidural anaesthesia was compared to general anaesthesia for ambulatory knee arthroscopy, shorter discharge times, decreased incidence of nausea and vomiting, and reduced postoperative pain were found [73].

Several advantages make epidural anaesthesia a favorable choice of anaesthetists. The risk of postdural puncture headache is extremely low. There is always a potential risk of unintentional dural puncture by either the needle or the catheter. A 0.5% incidence of accidental dural puncture during epidural needle placement was reported [74] and chance of having PDPH following this exceeded 50% in younger patients [75]. Onset of anaesthesia is slower and thus less threatening to patients. It can be 'titratable', i.e. the dose can be adjusted to the desired dermatome and the concentration can be varied depending on the motor block required.

The advantages of epidural anaesthesia must be weighed against several factors that compared negatively with spinal anaesthesia. Technically, it is more difficult especially in obese and elderly patients. The onset is slower than spinal technique and 15–20 min are usually required to attain adequate surgical anaesthesia. It is less reliable than spinal anaesthesia in providing a dense motor and sensory block, especially in the sacral area. Variation in dose response is wider and younger patients require significantly higher dose than elderly and obstetric patients [74]. The higher dose requirement also increase the risk of local anaesthetic toxicity. Backache is another problem. The risk of backache is higher and tends to last longer in young patients compared with spinal anaesthesia [76].

The technique for epidural anaesthesia for outpatient is basically the same as for inpatient. Lumbar epidural blockade is suitable for surgery of lower extremity,

Table 4
Local anaesthetics for epidural anaesthesia

Drug	Usual concentration (%)	Usual volume (ml)	Total dose (mg)	Usual duration (min)	
				Plain	With epi 1:200 000
Chloroprocaine	2–3	15–30	300–900	45–60	60–90
Lidocaine	1–2	15–30	150–300	80–120	120–180
Mepivacaine	1–2	15–30	150–500	90–140	140–200
Bupivacaine	0.25–0.5	15–30	37.5–150	165–225	180–240

Adapted and modified from Brown, [108], and Strichartz, [57], with permission.

laparoscopy, inguinal hernia repair and lithotripsy while caudal epidural approach is more appropriate for perianal procedure (Table 2). Short acting local anaesthetic agents should be the drug of choice; 2-chloroprocaine and lidocaine provide adequate anaesthesia for surgery up to 1 and 2 h, respectively (Table 4). For procedures with longer or unpredictable duration, one can add epinephrine to the local anaesthetic or repeat the dose through the epidural catheter rather than using longer acting drug. Although placement of catheter increases the risk of venous puncture from approximately 3 to 8%, this allows the anaesthetist to use a smaller dose without worrying about inadequate anaesthesia intraoperatively.

The use of 2-chloroprocaine deserves some discussion. Since it was made available in the US in 1952, there have been concerns about the neural toxicity following accidental intrathecal injection. Preservatives like sodium bisulphite was thought to be responsible [77]. In 1987, a new preparation using disodium EDTA was available in the market but it raised new concern about the high incidence of back pain associated with its use [78,79]. The back pain is deep aching burning in character and diffuse in the lumbar region, lasting at least 24 h [79]. This appears to be associated with larger doses of chloroprocaine (35 to 45 ml range). Hence, chloroprocaine should be restricted to very short outpatient procedure requiring small dose of local anaesthetic. In view of this, a new preparation of preservative-free chloroprocaine is now available.

6. Combined spinal epidural technique (CSE)

Since CSE was performed on a single spinal segment for lower limb surgery in 1982 [80], this regional technique has become increasingly popular during recent years. CSE anaesthesia offers advantages over the use of epidural or spinal alone. Compared to epidural anaesthesia, CSE has a faster onset and virtually no risk of clinically relevant intravascular injection. With an epidural catheter as backup for possible re-dosing, the anaesthetist can confidently administer a minimal intrathecal dose which can result in shorter duration of anaesthesia and recovery time. Furthermore, it offers increased flexibility because the anaesthetic duration can be extended using the epidural catheter.

However, this technique also combines the disadvantages of both the spinal and epidural technique. By combining the two techniques, it increases the complexity and the time for performing this procedure. With the puncture of the dura, the patient has the risk of postdural puncture headache. In this needle-through-needle technique, the risk of displacement of the spinal needle is high. The failure rate ranged from 4 to 16% [81,82]. Failure is also associated with inadequate length of spinal needle protruding through the Huber aperture of the epidural needle. By using a longer spinal needle with protrusion of its tip at least 12 mm beyond epidural needle, the failure rate can be decreased [82,83]. There is also concern about the migration of the epidural catheter into the same hole created during the dural puncture but a recent study showed that it was impossible to force a 16- or 18-gauge epidural catheter through the hole made with a 25- or 26-gauge spinal needle [84].

Most of the studies using CSE technique are in obstetric and inpatient population [85]. In 90 outpatients undergoing knee arthroscopy, CSE with 40 mg isobaric lidocaine resulted in very short favorable discharge times with few side effects [86]. About 10% of patients required epidural supplement intraoperatively. Without a backup of epidural catheter, one might use a higher dose for spinal anaesthesia which would prolong the discharge time. More studies are required to show the usefulness of CSE in the ambulatory setting.

7. Regional block for upper extremity

Regional anaesthesia offers many advantages for surgery of the upper limb. With anaesthesia confined to the upper limb, patients remain awake and can enjoy faster recovery and earlier discharge [24]. Complications such as nausea and vomiting are minimized and pain control is smoother, regional anaesthesia can reduce unanticipated admission in ambulatory setting [16,87] and result in cost-saving [14].

Table 5
Local anaesthetics for major nerve blocks

Drug w/epinephrine 1:200 000	Usual concentration (%)	Usual volume (ml)	Maximal dose (mg)	Usual onset (min)	Usual duration (min)
Lidocaine	1–1.5	30–50	500	10–20	120–240
Mepivacaine	1–1.5	30–50	500	10–20	180–300
Bupivacaine	0.25–0.5	30–50	225	15–30	360–720
Tetracaine	0.25–0.5	30–50	200	20–30	300–600

Adapted and modified from Strichartz, [57], with permission.

Time constraint is a major concern with this technique. This can be minimized by performing the block outside the operating room, either a regional block room or PACU. Actually, the extra time spent to perform the block can be offset by the rapid turnover and faster recovery of patient compared with general anaesthesia [16,87].

Different techniques can be used for major upper limb blockade: intravenous regional anaesthesia and brachial plexus block of different approach, i.e. interscalene, supraclavicular and axillary. Surgical procedures suitable for the particular regional technique are listed in Table 2.

Intravenous regional anaesthesia provides an extremely simple, safe and reliable form of regional technique for the surgery of hand and distal forearm. Onset is rapid and the surgeon can start prepping and draping once all the local anaesthetic is administered. Dilute (0.5%) prilocaine or lidocaine are the drug of choice. Disadvantages of this technique are tourniquet pain, possible toxic reaction following tourniquet release and rapid loss of analgesia in the immediate postoperative period.

The brachial plexus can be blocked with different approaches. Factors that determine the specific approaches are the site for surgery and the associated complications. Interscalene approach is most suitable for surgery involving the shoulder while axillary approach for surgery for the hand. The supraclavicular approach provides reliable, fast onset of anaesthesia with relatively small volume of anaesthetic, and is most likely to anaesthetize all the major branches of upper limb. The risk of pneumothorax, albeit rare, may result in unanticipated admission. This complication was addressed by Moorthy by using a lateral paravascular approach [88].

The axillary brachial plexus block is an accepted technique for the forearm and hand surgery. Three methods are used to localize the plexus: paresthesia seeking, transarterial and nerve stimulation. Although there was no significant difference in success rate among these three methods [89], transarterial technique has been gaining popularity because of the reports of increased success and decreased complication [26–28,90]. Standard paresthesia technique has been characterized by Mulroy [91] as probably the most common for the axillary block. However, in a recent editorial analyzing the controversy of complication associated with this technique, the author suggested that paresthesia technique may increase the likelihood of neuropathy [90]. Until there is large prospective study to confirm this argument, the practicing anaesthetist should choose the method they are comfortable with.

Interscalene brachial plexus block is the regional technique of choice for shoulder surgery. With recent advance in arthroscopic technique, there is an increasing popularity of shoulder surgery performed in the ambulatory surgery setting. Unfortunately, this type of surgery was associated with a 45% incidence of severe postoperative pain [92].

Interscalene blockade, either as the sole technique or combined with general anaesthesia, has been compared favorably to general anaesthesia in terms of pain control and better recovery [16,87,93]. The anaesthetist should be aware of the complications and limitations of this block as sole anaesthetic. Hemidiaphragmatic paresis following interscalene block has been reported to be 100% [94]. Although the consequent reduction of forced vital capacity (FVC) is not life-threatening in young healthy patients (27–34%) [94,95] it can cause the sensation of breathlessness and necessitate the conversion to general anaesthesia [87]. Hoarseness, as a result of blockade of recurrent laryngeal nerve, can increase the anxiety of an already nervous patient. Finally, activation of Bezold–Jarisch reflex in patients undergoing shoulder arthroscopy following interscalene block has been reported [96]. This reflex results in profound bradycardia and hypotension with the patient usually experiencing nausea and lightheadedness 60 min after the interscalene blockade. Therapy consists of atropine and/or ephedrine.

Lidocaine and mepivacaine are the drugs of choice for brachial plexus block (Table 5). For surgery less than 3 h duration, lidocaine 1.5% with epinephrine or mepivacaine 1.5% are ideal for this purpose. For surgery of shorter duration, plain lidocaine 1.5–2% is preferable. Bupivacaine with longer duration of anaesthesia may cause some concern in patients because of the slow return of normal function.

Recently, two new regional techniques are being used to improve pain control and recovery of patient undergoing outpatient shoulder arthroscopic surgery. When combined with general anaesthesia, suprascapular nerve block significantly improved pain control in the early postoperative period, reduced the consumption of analgesic and resulted in earlier discharge [12]. This method is applicable to arthroscopic rather than open shoulder surgery. The advantage of this block is the ease of performing compared to interscalene block. The other technique is modified interscalene block in which low volume (10 ml) and low concentration (0.125%) of bupivacaine is used in combination with general anaesthesia [97]. With this technique, the pain score was significantly reduced, 39% of patients did not require morphine during the hospital stay and patients reached discharge criteria significantly earlier. Advantages include less profound motor block (motor function almost fully recovered by 120 min) and smaller volume of injectate implying lower risk of systemic toxicity.

8. Regional anaesthesia for the lower limb

Peripheral nerve blockade for the lower limb is not as commonly practiced as in the upper limb. The main reason is that spinal or epidural technique offers an easy, quick and reliable technique for the anaesthesia of the lower limb. Anatomically, the nerve supplies to the lower limb, the lumbar and lumbosacral plexus, are not bundled together and easily accessible, making it technically more difficult and time-consuming to anaesthetize. The latter factor is particularly important in the ambulatory settings. Surgical procedures suitable for the particular regional technique are listed in Table 2.

Intra-articular instillation of local anaesthetic is the simplest form of anaesthesia for knee arthroscopy and is effective for diagnostic arthroscopy. When tourniquet and arthroscopic surgery is required, a more extensive anaesthetic is required. Anaesthetizing the lumbar plexus alone without blocking the sciatic nerve usually is enough for this purpose. The lumbar plexus can be blocked either through a posterior [98] or anterior approach, the latter is technically easier and is more commonly used in ambulatory surgery. In anterior approach, either separate injections to femoral nerve and lateral cutaneous nerve of thigh or one injection in '3-in-1' block described by Winnie can be used [99]. With '3-in-1' block of 20–30 ml volume of injectate, there is a high chance that the lateral cutaneous nerve of thigh or the obturator nerve are missed [11,98]. Patel described the satisfactory use of the '3-in-1' for outpatient knee arthroscopic surgery. It resulted in superior postoperative pain control, faster recovery and earlier discharge compared with general anaesthesia group [11]. Supplementation of '3-in-1' block with blockade of lateral cutaneous nerve of thigh was suggested to improve the success rate.

For foot surgery, three techniques (popliteal fossa block, ankle block and intravenous regional anaesthesia) can be used in ambulatory settings. Popliteal fossa block is a simple and effective procedure that is very useful for ambulatory surgery [100]. With the patient in prone position, a single injection of 30–40 ml of local anaesthetic is required to anaesthetize the sciatic nerve at this level. In experienced hands, this block can be finished within 15 min [100]. Supplementation with saphenous nerve block is needed if anaesthesia of the dorsum of foot or big toe is required.

Ankle block is also a very useful procedure for outpatient foot surgery like bunionectomy and neuroma excision [101]. Since there is only minimal disruption of ambulatory function, longer-acting local anaesthetic can be used and results in excellent postoperative pain control. However, at least three separate needle insertions are required to anaesthetize the five nerves, and additional time is required to wait for the block to work, making this a time-consuming procedure. Both the ankle block and popliteal fossa block do not provide adequate anaesthesia for the ischemic pain from the tourniquet placed on the thigh.

Intravenous regional anaesthesia (IVRA) for the lower limb is not as popular as its use in the upper limb. The major drawback is greater ischemic tourniquet pain when the tourniquet is applied at the thigh or calf level [102,103]. This can be minimized by placing the tourniquet in the ankle with good acceptance with patients receiving this anaesthetic [104]. Although the success rate of the latter technique was 80%, all procedures were successfully completed with additional local anaesthetic infiltration. The advantages of this technique are the simplicity and the rapid onset of the block.

9. Discharge considerations

Patients receiving regional anaesthesia require the same postoperative care as other ambulatory surgery patients. Central nervous system effects of local anaesthetics may prolong complete recovery after regional anaesthesia. It has been shown that patient postural stability was impaired 40 min after perivascular axillary block with mepivacaine [105]. For those patients who received peripheral nerve blockade, there is no need to delay their discharge until complete resolution of sensory and motor blockade. In fact, residual sensory block allows better pain control and is one of the advantages of regional anaesthesia technique. However, patients with residual block of an extremity should be well informed of the need to protect the extremity from any trauma due to the loss of sensation and reflex. A

sling is all that needed for a numb upper extremity while a bulky dressing is required to protect a numb lower extremity against injury. Crutches should be supplied to all patients with knee or foot surgery. Before discharge from the day surgery unit, patients should be instructed and supervised on the use of this walking aid.

When is it safe to permit patients to ambulate following spinal or epidural anaesthesia? Suitable criteria for ambulation after spinal anaesthesia include normal perianal (S4–S5) pinprick sensation, plantar flexion of the foot, and proprioception of the big toe [106]. No motor block should be present when a patient tries to stand or walk. To test the motor block, the clinician may ask the patient to touch both the right and left heel to the opposite big toe and to run each heel up and down the opposite leg to the knee [107]. A patient's ability to walk to the bathroom and urinate may be the best recovery tests after epidural or spinal anaesthesia because these abilities indicate the recovery of motor and sympathetic functions. Patients with spinal anaesthesia should be warned about the possibility of spinal headache.

Before discharge, patients should be given a phone number so that they can contact an anaesthetist or the regional anaesthesia program nurse in case of any concern about complication resulting from the regional nerve blockade. Patients should also be followed up in the postoperative day 1 to ensure complete return of neurological function.

10. Conclusions

Regional anaesthesia provides better postoperative pain control, avoids complications from general anaesthesia, such as nausea and vomiting, and results in faster recovery of patients. All these advantages are important in ambulatory surgery. However, there are several limitations with this technique. Extra time is required to initiate a nerve block. Therefore, the block procedure is preferably performed in a designated area outside the operating room. Regional anaesthesia is a technical specialty. Anaesthetists skillful in this area are required to ensure smooth running of the regional anaesthesia program and careful exact technique must be practiced in treating outpatients. Certain complications associated with regional anaesthetic technique, like postdural puncture headache, may not be acceptable to young and active ambulatory outpatients. Careful selection of candidates and technique is necessary.

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