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Ultrasound use for nerve blocks and management strategies in outpatient surgery

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INTRODUCTION

Advances in surgical technique favoring minimally invasive approaches and economic pressure to reduce hospital costs have led to a worldwide increase in the number of surgeries performed on an ambulatory or day-case basis, with patients admitted to the hospital on the day of surgery and discharged several hours later.

That trend is most pronounced in the United States, where the majority of surgeries are being performed as day-cases and a similar trend is expected in surgical centers across Europe as well.

The challenge for the anesthesiologist is to provide anesthesia that will combine pain and stress-free surgery with rapid recovery and good postoperative pain control to enable the patient to be discharged from the hospital capable of self-care in a home environment. Anesthesia related factors including insufficient postoperative pain control, drowsiness and postoperative nausea and vomiting (PONV) have been identified to be among the main reasons for delayed discharge and unplanned readmission after ambulatory surgery *(1, 2).*

Although ambulatory procedures are considered to be minor surgical interventions, a significant proportion of patients still experience moderate to severe pain after these procedures *(3),* especially after orthopedic surgery.

Regional anesthetic techniques have been shown to significantly reduce pain scores, postanesthesia care unit utilization, postoperative nausea and vomiting (PONV) and need for opioid rescue analgesia compared to general anesthesia in patients undergoing ambulatory surgery *(4).* Although it is reasonable to assume this should translate into earlier home readiness and shorter total hospital stay, such an advantage has not been consistently demonstrated for regional anesthesia in the ambulatory setting.

Introduction of ultrasound guidance for peripheral nerve block performance and perineural catheter placement has led to a reduction in block performance time, volume of local anesthetic administered and less intravascular injections, and resulted in lower need for opioid rescue analgesia compared to neurostimulation guided techniques *(5, 6,7)* however reduced overall complication rates compared to traditional techniques could not be demonstrated *(8).*

Ultrasound guidance is also used to facilitate the performance of blocking deeper lying neural structures (e.g. paravertebral blocks), however these procedures involve a greater risk of potentially serious complications such as pneumothorax or deep hematoma formation and the benefit of their use in ambulatory patients should be carefully weighed against these risks *(9).*

Orthopedic procedures involving upper and lower extremities are ideally suited to be performed using easy to learn regional procedures providing excellent operative anesthesia as well as postoperative analgesia.

GENERAL PRINCIPLES

Depending on type of surgery, patient and surgeon preference, regional nerve block techniques can be used as the sole anesthetic or can be combined with sedation or general anesthesia to improve patient comfort and procedure tolerance. If the later is the case, care should be taken to choose sedative/anesthetic drugs which will allow for rapid recovery of consciousness and carry a minimal risk of postoperative nausea and vomiting *(10).* If airway patency maintenance is an issue a laryngeal mask airway device may be preferable to endotracheal tube placement since it does not require the administration of muscle relaxant agents and is better tolerated by the patient reducing or precluding the need for intraoperative opioid administration.

Regional blocks should be performed prior to the procedure even if combined with general anesthesia, since they have significant opioid sparing effects, enhancing patient recovery by reducing opioid related side effects such as PONV, respiratory depression and drowsiness.

Performance of regional anesthetic techniques has been associated with increased induction times compared to general anesthesia *(4)* and therefore if possible, to reduce operation room occupancy, should be performed outside the OR in a dedicated "block room" or in front of the OR while it is being prepared in between patients.

If postoperative neurologic assessment is an issue then a perineural catheter should be placed prior to the procedure and a bolus of short acting or dilute long acting local anesthetic used to cover the operative period and allow for quick block resolution thereafter. After return of motor and sensory function and postoperative neurologic evaluation is completed a bolus of long acting local anesthetic can be administered to provide prolonged postoperative analgesia and the catheter removed before discharge from hospital or the patient discharged home with a portable pump delivering a continuous infusion of local anesthetic solution.

There are different types of portable pumps that can be used in an ambulatory setting. Simple dispensable elastomeric pumps deliver a fixed rate of local anesthetic and are easy to use not requiring any special intervention by the patient after being set up. Using more complex programmable mechanical pumps the delivery rate of LA can be adjusted and boluses administered as needed according to variations in pain intensity and the need for mobilization and performance of daily activities. Pumps can be set up to allow re-programming by the patient with limits set to maximum infusion rate and number of boluses administered or can be remotely controlled by medical staff after being contacted by the patient. Besides theoretical advantages, there is no clear evidence to show superiority of re-programmable pumps over modern fixed rate delivery systems *(11, 12, 13).*

The lowest concentration of local anesthetic providing satisfactory analgesia should be chosen for continuous infusion, ideally allowing for at least partial preservation of motor function (e.g. ropivacaine 0.2% or bupivacaine 0.0625%-0.125% at 6-8ml/hr for upper extremity blocks and 4-6 ml/h for lower extremity blocks).

If local organizational issues and safety concerns preclude the use of continuous regional techniques in ambulatory patients, single shot nerve block duration can be prolonged by the use of adjuvants such as dexamethasone.

Clear and easy to follow institutional protocols must exist for ambulatory patients discharged with a regional block in place. Motor and sensory function should be documented prior to block placement and at discharge and the patient receive verbal as well as written instructions on precautions necessary to protect the insensate body region. An immobilizing device as a simple sling or orthosis should be provided to prevent injuries to the upper extremity and crutches and/or locked orthosis to allow ambulation and weight bearing with an insensate or weakened lower limb.

If a perineural catheter is placed the patient should be instructed on proper care and how to remove it once the infusion runs out. Ideally the catheter should be removed by medical personnel and documented, however this may impose further organizational and economic burdens and a simple telephone interview to receive patient feedback may be sufficient and preserve cost-effectiveness and patient satisfaction *(14).*

Regardless whether the patient is discharged with a single shot or continuous nerve block, clear instructions must be provided to manage breakthrough and pain after the block wears off. A multimodal oral regimen combining paracetamol and nonsteroidal anti-inflammatory drugs (NSAIDs) or selective COX-2 inhibitors with tramadol for more severe pain is appropriate for the first 3-5 postoperative days. Ideally a basal oral regime of paracetamol should be started already at the hospital after an intraoperative intravenous "loading" dose. This may diminish discomfort related to the perineural catheter, which can itself be a source of mild pain, or relieve tenderness at the block performance site. NSAIDs may then be added towards the end of the expected block duration period to prevent or lessen rebound pain and tramadol or another oral opioid analgesic agent added in cases where more severe pain is expected.

UPPER EXTREMITY BLOCKS

Surgery of the entire upper extremity is particularly suited to be performed under regional anesthesia since all of its innervation is derived from a single neural structure – the brachial plexus, originating from the ventral rami of the 5th cervical to the 1st thoracic (C5 to Th1) nerve roots with minor contribution coming also from C4 and Th2.

Various approaches to the brachial plexus have been described using surface anatomical landmarks above and below the clavicle *(15).* The traditional approaches to the brachial plexus are the interscalene, supraclavicular, infraclavicular and axillary approach. Using ultrasound to directly visualize the components of the brachial plexus and surrounding structures has enabled anesthesiologist to be more flexible with their approach and tailor it according to the individual anatomy of the patient. It reduces block performance time, the number of needle passes and incidence of vascular puncture, shortens sensory block onset time and improves block success *(16).*

The space inbetween the fascia of the anterior and medial scalene muscles and covered by the prevertebral fascia contains the roots and trunks of the brachial plexus (Figure 1). Landmark techniques usually use the cricoid cartilage to mark the level of needle point entry lateral on the neck (C6 level). Blocking the plexus at this level has consistently produced excellent analgesia for shoulder surgery since it reliably blocks both the suprascapular and the axillary nerves, supplying the majority of sensory innervation to the shoulder joint. Traditonally up to 50ml of LA have been used for interscalene block. Ultrasound guidance has enabled precise deposition of LA immediately adjacent to individual nerve roots and/or trunks of the brachial plexus producing reliable blocks with much smaller volumes, thus decreasing concerns of local anesthetic systemic toxicity. A volume of 20ml of levobupivacaine will produce shoulder analgesia for 12-16 hours. Adding 8mg of dexamethasone to a long acting local anesthetic will increase block duration to nearly 24 hours *(17).* Interscalene block is linked to a high incidence of ipsilateral phrenic nerve block resulting in hemidiaphragmatic paralysis and therefore should be used with caution in respiratory compromised patients. Involvement of the recurrent laryngeal nerve is also a concern. The C8 and Th1 roots often remain spared by this block making it unsuitable for surgery involving the ulnar nerve distribution on the arm or hand.

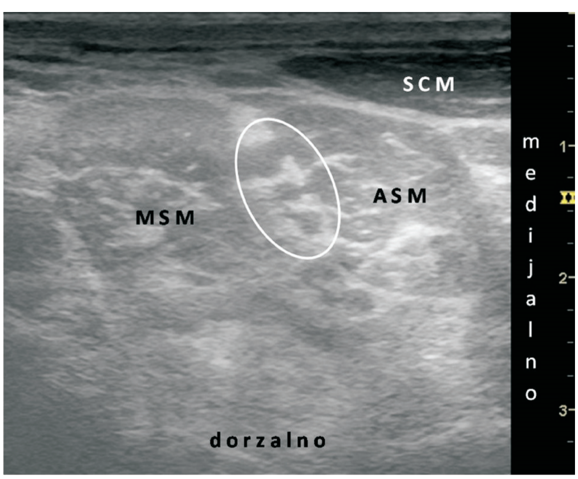

Figure 1. *Brachial plexus in the interscalene region. ASM – anterior scalene muscle; MSM – medial scalene muscle.*

Patients undergoing shoulder arthroscopy, rotator cuff repair and even arthroplasty have been successfully managed using interscalene brachial plexus blocks and consistently report less pain, lower opioid consumption and earlier commencement of passive range of motion exercises compared to those who received general anesthesia *(18).* Inserting a catheter for continuous LA infusion in the interscalene region can prolong analgesia in patients undergoing shoulder surgery and has successfully been used in ambulatory patients with no significant complications *(19).*

The trunks and divisions of the brachial plexus are tightly grouped together as they converge to pass above the first rib and below the clavicle adjacent to the subclavian artery, making this an ideal location to block the entire brachial plexus with a single injection. Prior to introduction of ultrasound guidance the supraclavicuar approach to the brachial plexus has fallen out of favor due to concerns of pneumothorax and a high risk of intravascular injection since the dorsoscapular artery often runs in between parts of the brachial plexus *(20).* With ultrasound guidance it is an excellent block for all surgical procedures on the upper extremity below the shoulder (Figure 2.). Due to its complete coverage of the brachial plexus it is also referred to as "the spinal of the arm".

The deeper position of the brachial plexus cords in the infraclavicular region may make ultrasound visualization more difficult compared to supraclavicular and axillary approaches, especially in obese or muscular patients. Injecting local anesthetic adjacent to the posterior cord decreases incomplete infraclavicular block rates due to ulnar nerve sparing. Due to easy catheter fixation and maintenance the infraclavicular approach is especially suitable for continuous analgesia after arm and hand surgery. Studies have demonstrated superiority of the infraclavicular approach to general anesthesia for day-case surgery in terms of postoperative pain control and patient satisfaction *(21, 22).*

The axillary block is the mainstay of regional anesthesia for elbow, forearm and hand surgery. It is a rather safe and easy to perform block. Due to its superficial location ultrasound provides excellent visualization of individual nerves surrounding the axillary artery and reduces the risk of vascular puncture. The musculocutaneous nerve

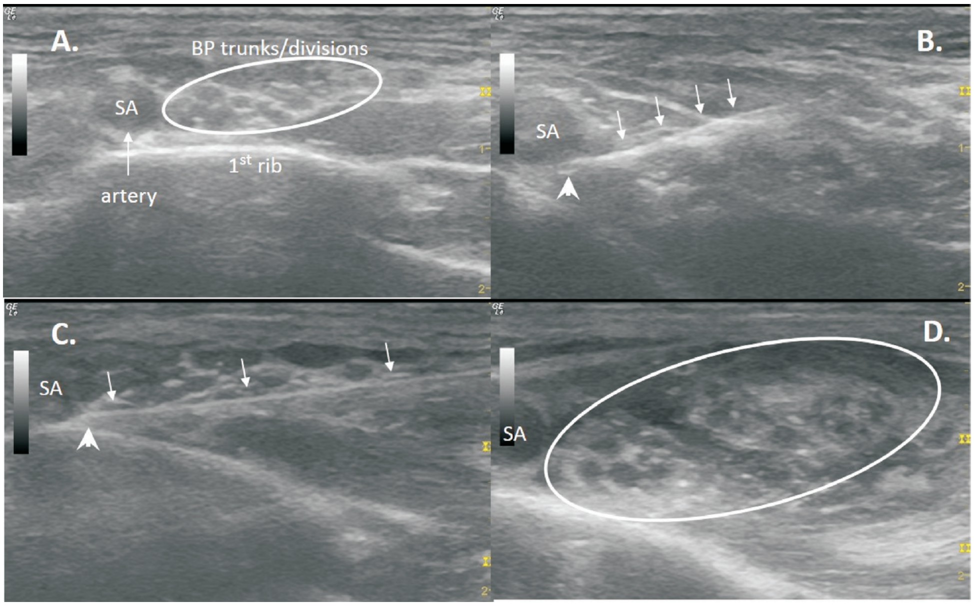

Figure 2. A. *Brachial plexus in the supraclavicular region.* **B.** *and* **C.** *In plane visualization of needle shaft (arrows) and tip (arrowhead) in "corner pocket" position.* **D.** *Trunks/divisions of the brachial plexus surrounded by local anesthetic. BP –brachial plexus; SA – subclavian artery.*

often separates high in the axilla from the rest of the brachial plexus and enters the coracobrachialis muscle often resulting in incomplete anesthesia and decreased tourniquet tolerance after paresthesia and neurostimulation guided techniques. Ultrasound guidance helps reliable identification and blockade of the musculocutaneus nerve at the axillary level.

Selective distal individual nerve blocks around the elbow are easily and quickly performed using direct visualization under ultrasound and can be used as the sole anesthetic for minor procedures on the wrist and forearm involving a single nerve teriotory or as "rescue" procedures following an incomplete proximal brachial plexus block.

Intravascular regional anesthesia (IVRA / Bier's block) has been a popular technique for below elbow procedures of short duration since it is simple to perform and has a high success rate. In short, IVRA is performed by exsanguinating a limb, applying a pneumatic tourniquet to cut off circulation and injecting local anesthetic into a vein distally on the limb. It provides good anesthesia for surgery involving soft tissue and superficial structures yet may be insufficient for procedures involving bone and articular structures. Drawbacks are risks of premature tourniquet deflation leading to systemic local anesthetic leakage, limiting it to short acting local anesthetics, poor tourniquet tolerance even with double chamber systems and negligible duration of postoperative analgesia. It can be used as a rescue procedure after incomplete brachial plexus and individual peripheral nerve blocks.

Local anesthetic infiltration can be used as the sole anesthetic for minor procedures on the wrist and hand or to supplement a regional block.

LOWER EXTREMITY BLOCKS

Lower extremity innervation is derived from the lumbar (anterior divisions of L1, L2, L3 and part of L4 spinal nerves) and sacral (L4, L5, S1, S2 and S3 spinal nerves) plexus.

Neuraxial anesthesia is the only way to provide anesthesia to the entire lower extremity via a single injection of local anesthetic. The advantages of spinal anesthesia for outpatient surgery are that it is simple, has a fast onset and low cost. Disadvantages include bilateral involvement, impaired ambulation, risk of urinary retention and fast onset of pain with block regression. Return of lower extremity motor function after spinal anesthesia is faster when short acting local anesthetics are used. Lidocaine has been a popular choice but its use has been discouraged after reports of a high incidence of transient neurologic symptoms *(23)*. Chloroprocaine is a short acting local anesthetic that has regained popularity for outpatient surgery in recent years. Block duration varies with the dose administered and roughly 40-60min of surgical anesthesia can be expected with a dose of 30mg, prolonged by about 15min with each additional 10mg increase in dose (*24)*. Another strategy is to use low-doses of hyperbaric ropivacaine or bupivacaine solutions in an effort to achieve unilateral spread with patient positioning and decrease block duration. In a prospective randomized trial doses of 8 mg of hyperbaric bupivacaine 0.5%, 8 mg of hyperbaric levobupivacaine 0.5% or 12 mg of hyperbaric ropivacaine 0.5% resulted in similar discharge time for outpatient inguinal herniorrhapy *(25)*. Doses of 4-5mg hyperbaric bupivacaine produce effective spinal anesthesia for outpatient knee arthroscopy *(26)*.

The lumbar plexus gives rise to the genitofemoral, lateral femoral cutaneous, femoral and obturator nerves. Combination with a sciatic nerve block will result in complete lower extremity anesthesia and when performed with short-acting local anesthetics has been shown to be associated with a superior recovery profile compared with general anesthesia in patients having outpatient knee arthroscopy *(27)*.

Lumbar plexus or psoas compartment block is a deep block since the plexus is situated at a depth of 60-100mm within the psoas muscle anterior to the transverse processes of lumbar vertebrae *(28)*. When used in an outpatient setting it should be reserved for skilled operators and major procedures where its analgesic benefits outweigh the risk of potential complications. The peritoneal cavity, great vessels and kidney all lie anterior to the psoas muscle and can be penetrated with excessive needle advancement. Retroperitoneal and psoas muscle hematoma formation is also a potential complication of this block.

The femoral nerve is easily visualized by ultrasound as it emerges bellow the inguinal ligament into the upper thigh covered by the fascia lata and iliac fascia (Figure 3), the latter separating it from the femoral vessels. It always lies lateral to the femoral artery. Femoral nerve block produces anesthesia of the anterior thigh and knee and has been used to improve analgesia, facilitate early mobilization and reduce opioid consumption and related side-effects after complex outpatient arthroscopic knee procedures like anterior crutiate ligament repair *(29)* and arthroplasty. Quadriceps muscle weakness due to femoral nerve block impairs gait control and weight bearing and care must be taken to discharge the patient with adequate knee immobilization and crutches as well as written and verbal instructions how to prevent falls. To decrease quadriceps motor inhibition adductor canal nerve block targeting the saphenous nerve in the subsartorial mid-femoral region has become a popular option *(30)* although its analgesic benefit in outpatients undergoing ACL reconstruction has recently been questioned *(31)*.

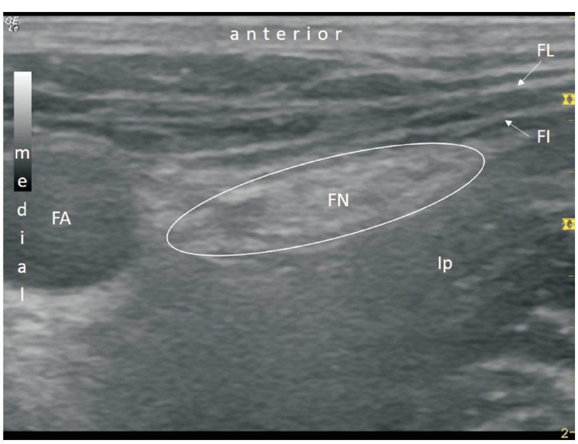

Figure 3 *Femoral nerve in inguinal region. FA – femoral artery; FI – fascia iliaca; FL – fascia lata; FN – femoral nerve; Ip – iliopsoas muscle*

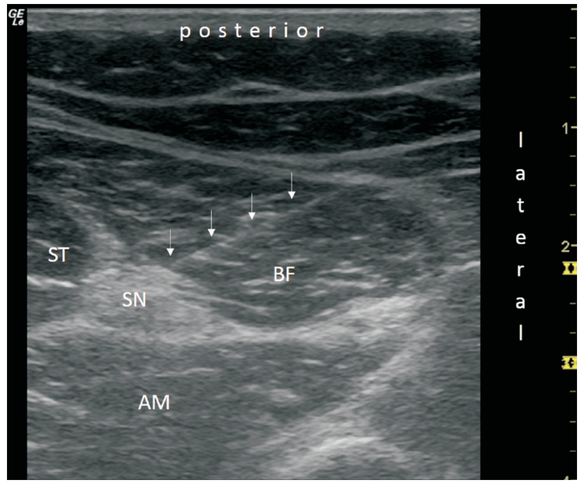

Figure 4 *Sciatic nerve in the upper thigh and in plane view of 26 gauge needle (arrows) AM – adductor magnus muscle; BF – biceps femoris; SN – sciatic nerve; ST – semitendinosus*

The sciatic nerve innervates the posterior thigh and almost the entire lower leg. Due to its deep location it is a technically demanding block when performed in the parasacral and gluteal region, however is readily visible with ultrasound from the subgluteal to popliteal region.

Proximal blocks of the sciatic nerve (Figure 4) are used to supplement lumbar plexus and femoral nerve blocks for surgeries performed on the thigh and knee, while blocking it at the popliteal region produces excellent anesthesia for most below the knee surgical procedures with the advantage of preserving hamstrings muscle strength and knee flexion. Sometimes a saphenous nerve block is added to improve calf tourniquet tolerance and provide complete anesthesia for surgeries involving the anteromedial portion of the lower leg. Continuous sciatic blocks provide good postoperative analgesia after day-case foot surgery without increasing complication and readmission rates compared to inpatients *(32)*.

Peripheral blockade of individual nerves around the ankle (ankle block) can be equally effective as a popliteal sciatic nerve block to provide both surgical anesthesia as well as postoperative analgesia after forefoot surgery *(33)*. It has the advantage of preserving lower leg motor function but requires multiple injections and does not cover the use of a calf tourniquet. Ultrasound guidance enables faster block performance and reduces the amount of local anesthetic lessening patient discomfort during block performance (Figures 5, 6).

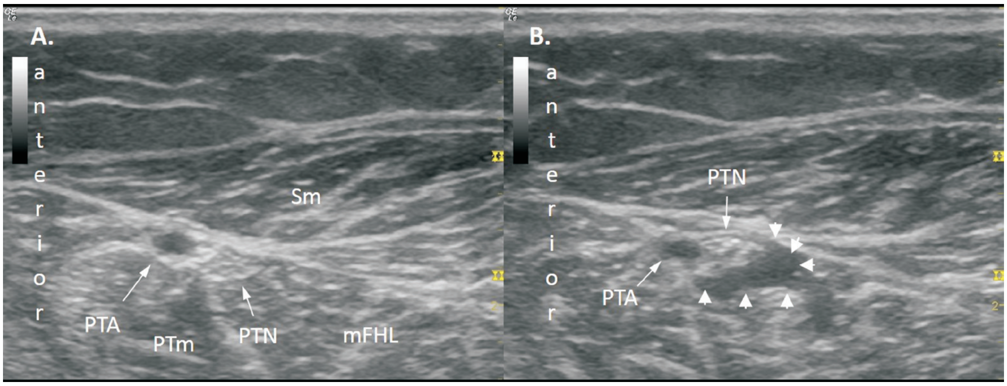

Figure 5. A. *Posterior tibial nerve and artery in the supramaleolar region* **B.** *Spread of local anesthetic (arrowheads). PTA – posterior tibial artery; PTN – posterior tibial nerve; PTm – posterior tibial muscle; mFHL – flexor hallucis longus muscle; Sm – soleus muscle.*

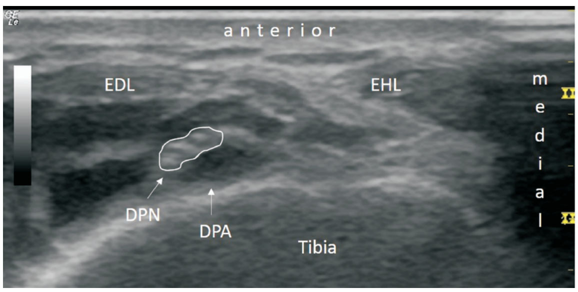

Figure 6. *Deep peroneal nerve at the level of the ankle. DPA – dorsalis pedis artery; DPN – deep peroneal nerve; EDL – extensor digitorum longus; EHL – extensor hallucis longus.*

TRUNCAL BLOCKS

The thoracic paravertebral space is situated between the vertebral body and intervertebral foramina medially, parietal pleura anterolaterally and superior costotransverse process dorsaly. Injection of local anesthetic into this space results in segmental anesthesia similar to an epidural block. Thoracic paravertebral blocks have been successfully used to reduce pain after breast surgery *(34),* minor and major thoracic surgery *(35)* and cholecystectomy *(36).* It has also been used for pain control after rib fracture management in an outpatient setting *(37).* A recent metaanalysis found PVB to be associated with less hypotension, PONV, urinary retention and failed block compared to epidural anesthesia *(38).* Nevertheles, paravertebral blocks have the potential for serious adverse effects, such as pneumothorax, vascular puncture and spread of local anesthetic into the epidural space. There is significant variability of spread of local anesthetic through the paravertebral space and sometimes injections at multiple levels may be necessary to achieve complete block of the surgical area. Injecting small volumes of local anesthetic at multiple levels may be a strategy to decrease the possibility of systemic toxicity as compared to achieve a greater segmental spread by injecting a greater volume at a single level. Inserting a catheter into the paravertebral space enables prolonged postoperative analgesia, however catheter dislogement and misplacement have occured relatively often prior to the introduction of ultrasound guided techniques *(39).* This technique should be reserved for skilled practitioners and its benefits carefully weighed against the risks in an outpatient population.

Transversus abdominis plane (TAP) block is achieved by administering local anesthetic into the fascial plane inbetween the internal oblique and transversus abdominis muscles producing unilateral segmental anesthesia of the abdominal wall. Ultrasound visualization has made this an easy to learn and easy to perform technique and safe alternative to paravertebral blocks to provide analgesia for surgical procedures in the periumbilical region and lower abdomen *(40).* TAP blocks performed in the subcostal area have been used to provide analgesia after cholecystectomy *(41),* however they have no effect on visceral pain and a recent study found only marginal benefits in reducing pain while coughing and on reducing opioid requirements in patients undergoing laparoscopic day-case cholecystectomy *(42).*

CONCLUSION

Increased pressure to enhance patient turnover and decrease hospital length of stay, together with the advancement of surgical and anesthetic techniques has led to a significant increase in outpatient surgery.

The use of regional anesthesia techniques consistently leads to reduced opiate analgesic requirements and improved postoperative pain and patient satisfaction scores in surgical patients. It has been shown that it's use in patients undergoing outpatient surgery results in a decrease in post anesthesia care unit utilization and reduces costs.

The use of ultrasound guidance for peripheral nerve block performance has decreased block performance time, enables visualization of the target nerve(s) and surrounding anatomy and real time imaging of needle path and local anesthetic spread leading to a decrease in local anesthetic volume and a lower incidence of accidental vascular puncture. Further studies are needed to show whether the wide spread use of ultrasound guided regional anesthesia will result in increased patient safety and shorter total hospital stay in patients undergoing surgical procedures on an outpatient basis.

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