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Perineural catheter analgesia as a routine method after ambulatory surgery – effective but unrealistic

Thank you Rick, for your very kind words of introduction. I would also like to express my thanks to the Board of Directors of the American Society of Regional Anesthesia and Pain Medicine for selecting my name for the 2010 ASRA Labat award. It is truly a great honour to be given this prestigious award named after a pioneer in the world of regional anesthesia. I almost did not make it here because of air traffic chaos and cancellation of most flights in Europe in the aftermath of the Icelandic volcanic eruption with heavy ash clouds. My only possibility was to take a train to Rome and then fly to Toronto. So here I am, what started as a “pain in the ash” has turned into a memorable experience in more ways than one. For the lecture I have selected a topic that I believe Dr. Labat would have approved i.e. pushing the frontiers of regional anesthesia by extending the benefits of such techniques outside the hospital and into the homes of patients undergoing ambulatory surgery. This presentation will attempt to update the reader on the current status of ambulatory catheter techniques for postoperative pain management.

Adequate postoperative pain relief is a prerequisite for successful ambulatory surgery and remains a challenge. Studies have shown that 30-40% of discharged ambulatory surgical patients suffer from moderate to severe pain during the first 24-48 hr (1, 2, 3). This pain decreases with time but may be severe enough to interfere with sleep and daily functioning (4, 5). Typically postoperative pain is treated by oral analgesics such as paracetamol (acetaminophen), NSAID’s and weak opioids. Although strong opioids such as oxycontin are commonly used in USA, their use in most countries is controversial in view of the fears of opioid dependence and diversion and the need for monitoring of a controlled substance in medically unsupervised patients. Furthermore opioid related side effects such as nausea, vomiting, drowsiness and difficulty with concentration are common sources of patient dissatisfaction. It has been shown in ambulatory surgery patients that opioid-related side effects are dose-dependent and that an increase in daily opioid dose of 4 mg equivalent morphine is associated with one additional clinically meaningful side effect, or one additional patient-day (6). In general, opioid-sparing multimodal analgesic techniques are recommended (7), however, this may not always be adequate because increasingly, previously inpatient surgical procedures are becoming ambulatory (7, 8, 9). Based on results from 2 surveys McGrath et al concluded that the problem of pain at home might be increasing due to increasing complexity of surgical procedures being performed on ambulatory basis. Up to 30% patients reported moderate to severe pain in spite of receiving multimodal analgesia regimens (9).

In USA major surgical procedures such as knee and shoulder reconstruction, gastric fundoplication, total knee replacement, splenectomy and adrenalectomy, prostatectomy, are being performed on a 23 hr admission basis (10). There seems to be a consensus that the number and complexity of ambulatory surgical procedures will continue to increase (10, 11). Optimal postoperative pain control for ambulatory surgery should be effective and safe, produce minimal side effects, facilitate recovery, and be easily managed by patients at home. Analgesia techniques should permit “normal” activities, additional analgesic supplements should be provided to cover any painful activity. Day surgery patients with severe pain at home do not always take their medication as prescribed and may even mix in their own analgesics. Clear instructions are therefore mandatory. Rescue analgesia medication should be provided if the prescribed analgesic is ineffective.
In 1998 we described the use of catheter techniques that allowed patients to self-administer local anaesthetics through disposable, elastomeric pumps for pain management at home (10). It was demonstrated that effective analgesia could be provided through incisional, perineural, periosseous, subalveolar (for maxillofacial surgery), intraarticular and subacromial catheters after a variety of ambulatory surgical procedures (12). In recent years elastomeric and other lightweight pump devices, improved catheters, general trend of avoiding opioids and the preference for non-opioid analgesic techniques has led to the increasing use of this technique for pain management after a variety of ambulatory surgical procedures (13, 14). Most of the recent studies are from USA where major ambulatory surgical procedures are performed more frequently than elsewhere (11). Continuing regional anesthesia in the home environment has been demonstrated to reduce analgesic consumption and sleep disturbance (13, 15).

Extending regional techniques at home – Perineural versus WCI

It is well established that regional techniques provide the most effective postoperative pain relief, it is far superior to that provided by opioids (16, 17). In ambulatory surgery the two most common techniques are perineural and wound catheter infusions (WCI). Ambulatory perineural catheters have been used for techniques such as interscalene, infraclavicular, paravertebral, axillary, psous compartment, femoral, fascia iliaca, sciatic, popliteal and tibial nerve blocks (13). In recent years more complex blocks such as ambulatory posterior lumbar plexus catheter (18) and C5-6 root/superior trunk catheter techniques have been reported (19). Pediatric ambulatory perineural techniques such as axillary, femoral, infraclavicular, interscalene, lumbar plexus and sciatic catheters have been described in children ranging from 4-18 years. (20). For WCI the catheter is not always strictly in the surgical wound, in the literature WCI techniques include catheters placed subcutaneously but also through the surgical incision at other (deeper) sites such as subacromial, intraarticular, intraperitoneal, periosseus, supra-or subfascial (12, 14).

Problems with perineural catheters at home

A review on ambulatory perineural techniques by Ilfeld and Enneking concluded that there is strong evidence for improved analgesia, sleep quality and patient satisfaction with decreased use of supplemental opioids (13). However, there are several problems with perineural catheter techniques. Correct identification of nerves is technically challenging with documented failure rates. Definitions for block success vary but an average of about 20% failure rate has been described, the reported success rate with ultrasound-guided blocks ranges from 55% to 100% (21). Ultrasound-guided blocks may reduce the risks for failures but will not eliminate them (21, 22). Another problem with perineural techniques is the unpredictability of the position of the catheter tip. In technically challenging blocks such as the three-in-one block the catheter was in the correct position in only 23% of patients in one study (23) and 40% of patients in another (24). The possibility of catheter misplacement during initial insertion or subsequent dislodgement will require use of rescue analgesics (13) Furthermore, peripheral blocks have a potential for significant complications such as nerve injury (25), catheter migration into a blood vessel leading to local anaesthetic toxicity (26), pneumothorax in spite of ultrasound guidance (27) and unintentional spread of blockade epidurally or intrathecally (28). Also, discharging patients with an insensitive extremity and lack of protective reflexes may result in accidental limb damage or injury from falls (29). For example, femoral nerve catheters for knee surgery may be associated with marked and prolonged motor blockade in some patients leading to weakness of the quadriceps and compromised proprioception which can increase the risks of falls and major complications such as peri-prosthetic fracture requiring further surgery and prolonged hospital stay (18, 30, 31). These and other reports of falls have led to changes in postoperative mobilization routines (30) or abandonment of femoral catheter technique for knee surgery (31). These complications were reported in inpatients, clearly the risks can be expected to be greater in the unsupervised or under-supervised patient at home. Ilfeld et al reported 3 falls (13%) at home in patients receiving bupivacaine for ambulatory posterior lumbar plexus block after hip surgery. The authors noted that falls could occur without
apparent quadriceps weakness and fall prevention strategies are necessary in all patients receiving perineural catheters for hip or knee surgery (18). In a more recent analysis of pooled data from 3 well-controlled studies Ilfeld et al noted a causal relationship between ambulatory continuous peripheral nerve blocks and risk of falling after knee and hip surgery; 42% of patients in study group required decrease in their infusion rate, 4 of 7 falls occurred after discharge. The authors recommended several steps to reduce risk of falls including the need for skilled nursing at home and education of physiotherapists, nurses and surgeons (32).

In a recent review of current techniques for postoperative analgesia after shoulder surgery Fredrickson et al concluded that the only effective regional anesthesia technique for both major and minor shoulder surgery is continuous interscalene block (CISB) and therefore the “gold standard” (33). In an accompanying editorial Hadzic et al pointed out that Fredrickson et al’s conclusions about continuous interscalene block were not based on controlled studies and that achieving the balance between shoulder analgesia and an absence of motor block and/or paresthesia in rest of the limb is challenging (34). The editorial also reminded the readers about the potential side effects of CISB such as hoarseness, Horner’s syndrome, diaphragmatic paralysis, paresthesia, and dysesthesia. The incidence of some of these side effects is not insignificant. The editorial questioned the label “gold standard” and concluded that although ambulatory CISB could be implemented in centres of excellence in regional anesthesia, it was questionable if an occasional user of such techniques could match the results reported by “super-specialized opinion leaders” (34). This author believes the same can be said for all ambulatory perineural techniques because of similar concerns due to potential risks and administrative challenges in managing medically unsupervised patients at home.

Why the poor acceptance of peripheral nerve blocks (PNBs) by anesthesiologists?
The efficacy of perineural catheter techniques for postoperative analgesia is well recognized since decades. A metaanalysis has shown that continuous perineural techniques provide superior postoperative analgesia to opioids (17). However, even for inpatients, where good nursing care and administrative follow-up are available, a majority of anesthesiologists have been unable in making this a routine method of analgesia (29). A US national survey showed that most anesthesiologists performed less than five peripheral nerve blocks monthly, lower extremity blocks were used less frequently than upper extremity blocks (35). Data from US National Center for Health statistics has shown that regional anesthesia was used in only 8% of ambulatory cases (36). Majority of teaching programs do not provide adequate training for peripheral nerve blocks. A US survey by Kopacz and Neal reported that the median number of peripheral nerve blocks during residency was only 45, most of these were not for anesthesia but for chronic pain procedures. In contrast epidural anesthesia was performed 175 times during residency, the authors noted that 40% of residents could be deficient in nerve block anesthesia (37). A more recent survey of members of Society of Ambulatory Anesthesia (SAMBA) showed that the use of regional anesthesia had increased but was restricted to a few techniques and discharging patients with insensate lower extremity was not prevalent. This survey did not address the issue of catheter techniques at home (38). These data are from USA, very little information is available from other countries. There is no evidence that teaching programs are any better elsewhere. A French national survey showed that less than 5% of inpatients received postoperative analgesia by peripheral nerve blocks and about 1.5% patients by epidural technique (39). A Swedish survey showed that the use of regional anesthesia (epidural and spinal anesthesia) for ambulatory surgery had in fact decreased, however, ambulatory perineural and WCI catheter techniques for postoperative pain were used in 9 out of the 86 (11%) ambulatory surgery centres. The question of preference of catheter technique i.e. perineural or WCI was not asked (8). There is a general feeling that the use of regional techniques is increasing but it is from a low base. A recent editorial noted “RA as a subspeciality still seems to be a minority interest and an art practiced and appreciated by the few rather than the many” (40).
Why wound catheter infusions (WCI)?

WCI have several advantages over perineural techniques for postoperative analgesia. The infusion of local anesthetics through wound catheters provides potent, site-specific analgesia. The technique is simple to perform, catheters can be placed under direct visualisation thus eliminating the risk of inadvertent penetration of vascular or neural structures. Additionally, only the area of surgery is affected allowing normal use of the extremity and early rehabilitation. This modality can be widely used, it offers the potential to provide complete analgesia or to substantially reduce the need of opioids.

Continuous wound infiltration with a disposable infusion pump, with or without a patient-controlled bolus, may provide several days of analgesia. Although these techniques may not always be as potent as continuous PNB’s, they are credited with being safe and simple to use. They can be easily combined with a single-injection peripheral nerve block, or combined with oral non-opioid analgesics as a component of multimodal analgesia. For minor surgical incisions WCI alone may provide adequate analgesia.

A metaanalysis of 44 randomized, controlled trials and a qualitative systematic review showed quite impressive results by WCI in a variety of inpatient and ambulatory surgical procedures (12). Overall, for all groups combined, the benefits of WCI included a 32% reduction in pain scores at rest and activity, 25% decreased need for opioids, 16% reduction in risk of PONV, 30% increase in patient satisfaction and shorter hospital stay by one day. However, all studies were not positive and the results were different for different outcome parameters such as pain scores, decreased opioid use and patient satisfaction. For example significant analgesic efficacy was noted in 10 out of 12 studies of patients undergoing general surgery (cholecystectomy, colorectal, abdominal aortic aneurysm, inguinal hernia) but in only three studies the analgesia lasted through postoperative day 2. Impressive results were also seen in cardiothoracic surgery (15 randomised controlled trials /RCTs) which included thoracotomy and sternotomy, in orthopedic surgery (16 RCTs) which included anterior cruciate ligament (ACL) reconstruction, total hip and knee replacements, major shoulder and spine surgery and in lower abdominal procedures (C. section, hysterectomy, retropubic prostatectomy (14).

In a new metaanalysis of 32 RCTs, analgesia after WCI was noted only in patients undergoing gynaecological and obstetric surgery at 48 hr but not after other types of surgery. The authors also noted reduced opioid consumption and shorter length of hospital stay, the latter of doubtful clinical significance. The risk of side effects was similar to that in the control group. The only difference was in the incidence of wound breakdown, surprisingly it was lower in patients receiving local anesthetics in their catheters. In general, higher quality studies (Oxford score > 4) found a more frequent positive outcome in pain scores, opioid requirements and hospital stay. In this metaanalysis the authors restricted themselves to the study of catheters in the surgical wound only, they excluded all studies where “wound” catheters were placed in other locations such as intraabdominal, mediastinal, extrapleural, subacromial, intraarticular etc. they also excluded all patients undergoing orthopedic surgery (41). It is not surprising that the results were somewhat different from those of metaanalysis by Liu et al who included patients undergoing orthopedic surgery, they were also less strict about catheter position of wound catheters. The exclusion of orthopedic patients is unfortunate because some of the best results with wound catheters have been reported in this group of patients (14, 42). The results are particularly impressive when a modified WCI technique is used for major lower extremity joint surgery. High-volume local infiltration anesthesia (LIA) technique, which also includes an intraarticular catheter for 1-2 top-ups, has changed orthopedic practice in several countries because of impressive reductions in hospital stay in patients undergoing hip and knee arthroplasty (43, 44, 45). Currently about 75% of all total knee arthroplasties are performed with the LIA technique in Sweden (46). Heterogeneity between published studies makes comparisons difficult, this issue is taken up in both metaanalyses (14, 41) The importance of catheter placement is addressed later in this paper.
Problems with WCI
The primary risk from peripheral infusions of local anesthetics is direct tissue toxicity such as myotoxicity. Although there are supportive laboratory data, the clinical experience is that such injuries are rare in the concentrations used for infusion (42). There is also a potential concern about local anesthetic toxicity, wound infection and delayed wound healing. In the Liu et al. metaanalysis which included 2407 patients no cases of local anesthetic systemic toxicity were reported, the incidence of catheter or pump failure was 1.1% (14). Concerns about wound infections seem unfounded, the reported wound infection rates in the metaanalysis were similar between active (0.7%) and control groups (1.2%) (14). This is consistent with the results from the second metaanalysis (41) and our own experience with ambulatory WCI since 1997. Some authors have commented on the high cost of disposable infusion devices as a drawback of WCI (14, 47).

In their metaanalysis and qualitative review Liu et al. concluded that WCI was associated with “improved analgesia, reduced opioid use and side effects, increased patient satisfaction and, perhaps, reduced hospital stay. The most notable feature was consistent evidence of these benefits across a wide range of surgical procedures, location of wound catheters, and dosing regimens accompanied with low incidences of catheter-related complications. Both the efficacy and technical simplicity of this technique encourage its widespread clinical use” (14). These conclusions about WCI are supported by an expert panel of Australian and New Zealand College of Anaesthetists in their latest report (2010) on evidence-based recommendations for postoperative analgesia (48).

Equipment and home care cost issues
Controlled clinical studies that address the issue of performance of pumps, catheters and their cost-effectiveness are generally lacking. The optimal equipment for ambulatory perineural or WCI techniques should be determined by controlled trials not based on claims by device companies. Simplicity and safety are not mutually exclusive, the selected device should provide safe delivery of local anaesthetic with good flow-rate accuracy and infusion flexibility.

A large number of pump devices are available to deliver local anesthetics as patient-controlled boluses, continuous infusion or a combination of both. The pumps can be electronic, battery-driven or the more commonly used elastomeric balloon devices. Although electronic pumps provide more reliable infusions and have alarms for warning of catheter occlusion or pump malfunction, patients seem to prefer elastomeric pumps because of their simplicity (49). Modifications in elastomeric pumps and catheters are made frequently by manufacturers (there are more than 10 manufactures of elastomeric pumps alone) with unsubstantiated claims of superiority in comparison to previous models. The catheters can be few-holed “epidural” catheters or multiple-holed fenestrated catheters. There are few comparative studies to guide the user regarding the performance of these pumps or catheters. A recent trend in WCI is the promotion of multihole, fenestrated catheters with the claim that such catheters provide better distribution of local anesthetic than the regular non-fenestrated (cheaper) catheters. However, there is no published evidence to support this claim. In many cases the equipment is pre-packaged as pump plus fenestrated catheter so that the consumer has no choice but to use the expensive catheter. A recent WCI study compared wound spread of a 20 ml bolus through 15 cm multiholed catheters versus triple-orifice epidural catheters in patients undergoing total hip arthroplasty. The wound spread was evaluated using radiolabeled saline. There was no difference between the catheters in wound spread of injectate (50). Also, all multi-holed catheters are not created equal. An experimental study of 4 commonly sold fenestrated, multihole catheters (I-Flow, Pajunk, Baxter, Polymedic) showed that proximal holes infused better in Polymedic catheters while infusion was predominantly through distal holes in I-Flow catheters. Uniform infusion through all catheters was seen only in Baxter and Pajunk catheters, these catheters were also less likely to break on pulling (51). The clinical importance of these findings needs to be evaluated in controlled studies.

In our original study we used a simple disposable elastomeric device (I-Flow) and a regular 3-holed epidural catheter. Up to 10 boluses of 10 ml on demand were possible, this was
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considered adequate for up to 2 days of analgesia after a majority of surgical procedures. The patients were instructed to open and close a clamp to receive a bolus. No major problems were noted in that study or in a subsequent study where our experience in over 600 patients was reported (12, 52), the cost of the device was 15 US dollars (12). Due to the potential risk of accidental overdose if patients failed to close the clamp, modifications in pump design have resulted in safer pumps. Today many pumps also have possibility for boluses and/or continuous infusion. Currently, several companies produce disposable elastomeric pumps, the costs range from US $55-$500 (13), the typical cost is about US $200-$280 (14). Nevertheless, it is unclear to this author why the new devices should cost more than 20 times the price of the original pump. This may be due to reimbursement issues in USA, the largest market currently. It should be noted that other devices by competitors are also very expensive now.

The total costs for WCI and perineural catheters will be different, clearly they will be greater in patients receiving perineural catheters. In addition to the costs of performing (with or without ultrasound guidance) and maintaining the perineural blocks, there will be added costs of home care. There is no consensus on what constitutes optimal follow up for perineural catheters at home. In some lower extremity blocks decrease in infusion rates may be necessary to reduce the risks of falls (32). Daily anaesthesiologist call and 1-2 daily home nursing visits are common. Catheters can be removed by patients or caregivers with instructions given by a provider over the phone (13). There are no good data about the costs of these activities. In one report the cost for a 2 hr nurse visit program was US $ 250 (20). The potential economic benefits of ambulatory perineural catheters are virtually lost in countries with state financed health care systems because such labor-intensive, high cost follow-up routines at home just mean shifting of costs from the same common source of funding.

By contrast the costs of WCI follow-up are modest because of the simplicity of the technique and minimal risk of complications. In Sweden only a 5 minutes telephone follow-up call by the PACU nurse is considered adequate. We have not seen any major problems with this routine in the last 13 years. In about 5% of patients catheters need to be removed by healthcare providers, this is similar to that reported for perineural catheters (13). Routines for discharge criteria, patient selection, patient education, verbal and written instructions, contact numbers in case of problems and rescue analgesia are similar for both WCI and perineural catheter techniques (13, 53).

Future perspectives
Because of relatively recent evolution of ambulatory catheter techniques many questions need to be addressed by controlled trials. Reviewing the literature on ambulatory perineural infusions Ilfeld and Enneking concluded that future investigations should include determining which patients and procedures benefit most, the optimal local anesthetic, concentration and adjuvant, the most advantageous delivery regimen and dosing structure, the optimal catheters and their placement, and infusion pumps, the safest frequency of patient contact and method of catheter removal and whether additional outcomes are affected (13). Similar questions apply to WCI techniques, much work remains to be done to find the optimal catheter placement, dose-response studies, relationship between volume and concentration of local anesthetics and the role of adjuvants. Comparative studies are also necessary to identify the most appropriate regional techniques for different surgical procedures (54). The relative contribution of different anatomical structures also needs to be evaluated. The importance of appropriate catheter placement for WCI has been demonstrated in recent studies in patients undergoing colon surgery, prostatectomy, nephrectomy, Caesarean section and major lower extremity surgery (42, 55-58). Well-controlled studies have shown that pre-peritoneal catheter placement was highly effective for postoperative analgesia after open colonic surgery (55), subfascial catheter technique was as effective as epidural analgesia after Caesarean section (56), and high-volume local infiltration analgesia (LIA) technique, which also involves intraarticular catheter placement, was superior to epidural technique for hip (43) and knee (44) replacement surgery.

Theoretically, direct application of local anesthetics to wounds is a rational approach to block pain transmission from nociceptive afferents. Local anesthetics also inhibit inflammatory
response to injury and thereby may reduce pain and risk of hyperalgesia. Sustained duration local anesthetics may provide up to 96 hr of analgesia after a single injection and would further improve on simplicity by removing the requirement for any infusion pump equipment (57). These ultra-long acting local anesthetics can be expected to have a more important role in the wound rather than perineurally. Additional peripheral pharmacologic agents are also being examined for sustained postoperative analgesia, these include vanilloid receptor (TRPV1) agonists (capsaicin) (58), peripheral NSAID’s (59) and tricyclic antidepressants. (60). All of these represent potentially valuable means of providing nonopioid analgesia directly to the periphery (47).

Some may argue that WCI can never be as effective as perineural catheter techniques particularly after major orthopedic surgery. There are some supportive data for both techniques but good head to head comparative studies are lacking (42, 54). The conventional wisdom regarding superiority of epidural technique for postoperative analgesia, valid for decades, is now challenged by evidence that peripheral blocks may be as good or better for thoracotomy (61, 62), hip (63) and knee arthroplasty (64, 65). Another common belief that femoral nerve block alone cannot provide adequate analgesia after total knee arthroplasty has been refuted by results of two metaanalyses (64, 66). Based on data from 10 RCTs a metaanalysis showed that single shot femoral nerve block was highly effective for pain relief after total knee arthroplasty, there was no additional benefit of combining it with sciatic nerve block or indeed of continuous infusion (66). Only similar controlled comparisons can show whether the current belief about the superiority of ambulatory perineural techniques over WCI is justified. Such studies should also address technical failures, side effects, home care and cost-effectiveness issues to demonstrate which of the two techniques is most appropriate for a particular surgical procedure.

Summary
Inadequate analgesia remains a problem following ambulatory surgery. The success of such surgery depends to a large extent on both effective control of postoperative pain and minimization of side effects such as sedation, nausea and vomiting. Home-based continuation of regional analgesia is a relatively new method of achieving prolonged pain relief. Small, disposable pumps preloaded with local anesthetic with pre-set hourly infusion rates or self-administered bolus infusions have been shown to provide effective analgesia at home. The two main techniques are perineural and WCI. Current evidence suggests that both are effective, comparative studies are lacking. Although very effective, perineural techniques are technically challenging and require labor-intensive and expensive home care that can only be provided in few specialized centres. The disappointing past experience with implementation of perineural catheter techniques in inpatients suggests that it is unrealistic to expect their routine use in most ambulatory centres. WCI is a simpler, safer and less expensive alternative and therefore more likely to have a more widespread use. Comparative studies are necessary to identify appropriate cost-effective indications for both techniques.

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