



REVIEW: Regional Anesthesia Options for Knee Surgery - 2018.

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1. INTRODUCTION

Regional anesthesia started over one hundred years ago with tissue infiltration techniques. Tissue infiltration techniques need a lot of local anesthetic drug, and only gave short duration analgesia. Also, the extent of the tissues nerve blocked was limited. Next physicians discovered that local anesthetic injected onto large nerves lying proximal to the surgical field produced much more consistent analgesia, much longer lasting analgesia and that less drug volume was needed.

The techniques of injecting these peripheral nerves evolved further. Initially drug was injected blindly percutaneous into a palpated space that hopefully contained the nerve. A modest majority of nerve block attempts ended in success.

By 1920 it was realized that if patient paresthesia could be elicited by the blindly inserted nerve block needle, the success and quality of the nerve block was improved greatly. Nerve location by paresthesia became the Gold standard of peripheral regional anesthesia until 1980. Successful nerve block rates approached 90% of attempted nerve blocks.

Around 1980 nerve location by electrostimulation via the needle became popular. It was found to produce even more reliable nerve blocks. Success rates climbed to 98%. The pinnacle of peripheral regional anesthesia was reached in about 2005 when widespread use of the ultrasound enabled visual guidance of the nerve block needle. Nerve blocks now were exceedingly safe and success rates were 100% if the patient had standard anatomy. These above comments are generalized for regional anesthesia. There are a few specific nerve blocks where ultrasound guidance does not and cannot improve upon the established safety and efficacy of the particular nerve block enjoyed by surface landmark and electrostimulation guidance. They tend to be the deeper nerve blocks, e.g. the psoas compartment block. There are many blocks where not using ultrasound guidance could be argued to be now negligent, but none pertaining to the leg.

Many different needle insertion positions for nerve blocks were developed since ultrasound guidance became widely available. From 1980 steadily through to 2005 the number of leg nerve blocks being performed became

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massive in numbers. If a peripheral nerve block was not performed then neuraxial anesthesia was the standard. It was a rare patient who had a knee arthroplasty with purely general anesthesia and no nerve blocks.

For TKA surgery, for the twenty-five years spanning from about 1980 to 2005, peripheral nerve blocks were most commonly used, combined with a general anesthetic or a spinal anesthetic. A small shrinking number of centers favored using epidural blocks for both the primary anesthetic and the postoperative analgesia. Spinal anesthesia is also popularly utilized as the primary anesthetic, combined with the peripheral nerve blocks. That was perhaps more so in cultures with less population obesity. Peripheral regional anesthesia techniques resulted in patients (i) using the lowest total amounts of opiates, (ii) using opiates for the least number of hours after surgery, (iii) reporting the lowest cumulative pain score over the first three days, and (iv) having best long-term analgesia results as well.

Injecting long acting intrathecal opiates with a spinal block did experience a surge in popularity in recent years but serious side effects have curtailed this practice.

There is currently no universally agreed gold standard for regional anesthesia for knee arthroplasty. Combined multiple peripheral nerve blocks are the best contenders for claiming to be the gold standard for best analgesia and best total outcomes. They can provide 100% post-surgical analgesia for 12 to 20 hours (depending on drug choices), and then be easily extended beyond that provide 90% analgesia needing only oral non-opiate analgesic supplementation.

From about 2010 onwards some orthopedic surgeons started to prohibit their patients being treated with peripheral nerve blocks. They substituted the loss of nerve block analgesia with their own administered infiltration techniques around the knee, particularly for arthroplasty surgery. It was as if anesthesia had regressed by 100 years. Anesthesia practice for knee surgery remains diverse and patterns are still evolving.

In the far past patients were kept immobile in bed for 7 days to “rest and recover” after knee arthroplasty. They experienced DVTs and thigh muscle atrophy. Earlier mobilization of patients on the late second day or the third days after arthroplasty reduced the DVT risk, and loss of muscle strength. Whether now pushing active mobilization earlier, onto the same day as surgery or before the first breakfast at the cost of diminished pain control has any patient outcome advantage is speculative. It could even result in some worse outcomes. This drive for even earlier mobilization is part of why surgeons are promoting periarticular infiltration blocks. No scientific evidence validates this as patient beneficial yet.

When one considers that chronic pain syndrome is the primary indication for total knee arthroplasty it is logical that the treatment of the chronic pain should be primary goal of the total therapy and not simply the insertion of synthetic articular surface. Only a modest fraction of knee patients become 100% pain free in the same month of surgery. For 34% of the patients the pain after 6 months is still intolerable, and 80% who used opioids before surgery have failed to be weaned off the opioids at 6 months after surgery. There should be massive maximal perioperative strategy to utilize regional anesthesia to minimize peri-operative opiates usage as long as is feasible. Good pain relief only for 6 hours after surgery is insufficient.

This lecture will focus on evaluating and teaching the multitudinous options of regional anesthesia for orthopedic surgery. This is field of medicine rich in strong opinion with as little quality scientific evidence to defend a stand point as there is to oppose the viewpoint. Very few anesthesia choices for knee surgery are litigiously wrong, nor universally right.

2. TYPES OF KNEE SURGERY

The most painful surgery is a total knee arthroplasty (TKA). Other surgeries can be above-knee amputations, below knee amputations, through-knee amputations, knee ligament and cartilage surgery, arthroscopy, patella surgery, and repair of periarticular fractures of the distal femur or proximal tibia.



3. ANATOMY OF THE KNEE NERVE SUPPLY.

The upper limb can be totally blocked with a single injection. The lower limb however needs two or three nerve blocks for complete analgesia of any large part. There are two separate nerve plexuses supplying all these nerves; (a) the lumbar plexus found within the psoas compartment, and (b) the lumbar-sacral plexus found at the parasacral position in the greater sciatic notch of the buttock.

For total **knee** analgesia for all knee surgeries the following nerves need to be blocked.

- i. The femoral nerve for the distal femur and the quadriceps muscle and the anterior joint capsule.
- ii. The saphenous nerve, a branch of the femoral nerve, supplies the medial side of the knee part of the medial joint capsule and the medial patella tendon and patella tubercle. The saphenous nerve can be blocked separately. The saphenous nerve is however included with a femoral nerve block
- iii. The obturator nerve. It supplies part of the medial side of the thigh skin, the large majority of the hip adductor muscles, and the medial joint capsule.
- iv. The sciatic nerve. It supplies the posterior knee joint capsule and the hamstrings behind the knee joint, and the proximal tibia.
- v. The posterior cutaneous nerve of the thigh (PCNT). It is also called the posterior femoral cutaneous nerve. It is an accompanying nerve of the sciatic nerve down to the ischial tuberosity. Any sciatic nerve block proximal to the ischial tuberosity will include a block of the PCNT.
- vi. The Nerve to the hamstrings. This seldom named nerve is mostly considered simply a branch of the tibial nerve portion of the sciatic nerve. It can however be distinctly separated from the sciatic nerve from the parasacral region onwards. It remains close to the sciatic high down to just above the ischial tuberosity and the first attachments of the hamstrings. Thereafter it is buried within the hamstrings. This nerve's one importance is to ignore hamstring twitches as a marker of location of the nerve block needle onto the sciatic nerve sign for any nerve block from the ischial tuberosity level to distal. If the hamstrings need to be blocked any of the buttock sciatic nerve blocks can be used proximal to this point. They are the approaches of Mansour, Labat, Winnie and Raj. The hamstrings specifically need to be blocked when a hamstring tendon is to be harvested for knee ligament repairs.
- vii. The lateral cutaneous nerve of the thigh is very rarely needed for knee surgery as a lateral incision is very rarely used. If it is anticipated that this nerve needs to be blocked, it can be blocked specifically and separately below the groin using ultrasound guidance. Best it is well blocked with a lot of other needed nerves with a psoas compartment block.

Not all of these nerves need to be blocked for all knee region surgeries. Some can be omitted with good knowledge of the surgeon's style and the actual surgery, and 100% analgesia still achieved. For example, incisions very seldom encroach on the skin supplied by the posterior cutaneous nerve of the thigh, except the rare trans-joint knee amputation.

Another factor is whether a tourniquet will be used or not. If so, and the surgery is planned to be done awake upon the patient, it is good to include the lateral cutaneous nerve of the thigh to avoid a need for deep sedation. Many patients cannot tolerate a tourniquet upon un-anesthetized skin after 15 minutes of tourniquet ischemia.

Lastly it has long been a surgeon dictated fashion to only partly nerve block the knee and to prescribe opiates for the unblocked pains. The merits of any single nerve block can be measured by the extent to which they reduce a group mean PCA morphine consumption in a 24-hour period. Generally, morphine PCA, compared to an untreated control group has to be reduced by 50% and more before the patients start to report reduced pain scores as well. A femoral nerve block alone reduces total knee arthroplasty (TKR) post-surgical pain by 60%. Adding an obturator nerve block adds an extra 10% PCA morphine reduction and the sciatic nerve an extra 30% PCA morphine reduction. A patient privileged to receive all three nerve blocks (obturator, femoral, sciatic) will have zero pain on zero opiates after surgery, for the duration of the nerve blocks after a TKR.

Because it is not a rare event that TKR surgery injures the sciatic nerve, specifically the common peroneal nerve portion, some surgeons are scared of an anesthesia provider nerve block injuring the common peroneal nerve could occur. The surgeon then fears the surgery will be blamed for that nerve injury. So those



surgeons prohibit a sciatic nerve block being one on the TKR patients disregarding the benefit to thousands of patients. An anesthesia induced sciatic nerve injury is very rare and is avoidable.

The common peroneal nerve component is the most vulnerable-to-injury nerve of all peripheral nerves. The common peroneal nerve is unusually vulnerable to injury because;

- i. It has a denser epineurium than other nerves,
- ii. It has a long path crossing the lateral distal popliteal fossa and knee joint capsule where its blood supply is tenuous from a single end artery. The surrounding tissues are poorly blood supplied so cross diffusion of oxygen as a rescue oxygen source is poor, and
- iii. It is the largest body nerve running over bone close to the skin, namely the neck of the fibular. (iii) its subcutaneous course over the neck of the fibular. It has no cushion and is easily crushed, bruised or stretched.

Nerve blocks are general performed proximal to those vulnerable nerve sites, and do not unusually cause nerve injuries.

For the above reasons this author only ever injects the popliteal nerve from the medial side, and only injects the tibial nerve component. This leaves the common peroneal nerve component, lying on the lateral side of the sciatic nerve, well alone. The nerve blocks done this work just fine. This technique would assist in the author arguing against being blamed for surgeon induced common peroneal nerve injury.

It can be noted about knee arthroplasty surgeons as a generalization that:

1. The surgeons do recognize the severity of post-TKA and the humane need to treat it.
2. Surgeons do generally acknowledge the general merits of regional anesthesia to treat pain and improve general patient outcomes. They just wrongly assume local anesthetic used in any fashion will achieve all the same benefits as a best regional anesthesia technique.
3. Many surgeons have stated the wish to eliminate the role of the anesthesia provider in performing regional anesthesia¹².
4. Surgeons have claimed that by avoiding anesthesiologist nerve blocks they save salaries, hospital costs, time, and this allows more patients to be operated in one day. Note bene: There is no individual patient benefit in that claim. The claimed time saving is untrue. It has been shown in multiple studies that patients with nerve blocks established before cutting recover so much faster whether they had an additional general anesthetic or not. The faster recovery saves more time than what the extra that it took to perform the nerve block in the operating room. Many teams perform the peripheral nerve block prior to the patient entering the operating room.
5. Surgeons incorrectly believe avoiding femoral nerve block will avoid patient falls after surgery.

5. COMMENTS AND PRACTICAL TIPS ON SPECIFIC NERVE BLOCKS.

A. Spinal anesthesia.

This is one of the most popular primary anesthetics for TKA. It has no advantage for younger healthy patients over general anesthesia. The older the patient and the more they have accumulating co-morbid disease, the greater the benefits of spinal anesthesia will be over general anesthesia. The popularity of spinal anesthesia has been partly driven by using it as an opportunity to inject long acting opiates intrathecal. A single dose of long acting spinal opiate was once observed to produce 24 hours of opiate analgesia in some patients. There are however a lot of problems associated with spinal morphine. So, this invalidates the past prime attraction to using spinal long acting opiates, and thus also one rationale reason for even doing a spinal anesthetic.

Intrathecal morphine for knee arthroplasty.



Long ago it was observed that the blood brain barrier could be bypassed by intrathecal injection of morphine. Analgesia was achievable with a reduced milligram dose, and a few individuals had extended analgesia lasting 24 hours. Later experience revealed that by removing the blood brain barrier to the morphine higher Central Nervous System (CNS) morphine dose to the CNS were being achieved. The extended effect of intrathecal morphine analgesia is due to increased CNS production of the M6G and M3G morphine metabolites. M6G is responsible for the analgesia, nausea and pruritus. M3G causes the respiratory depression. M6G and M3G being highly water soluble are relatively trapped within the blood brain barrier causing their extended effects.

The problems associated with intrathecal morphine:

- The analgesia is inconsistent and 40% of patients need extra opiates within 6 hours after injection.
- It increases the pain the patient experiences beyond 24 hours over that that what they would have experienced had no intrathecal morphine been injected. (laboratory study confirmed)
- Administering supplementary opiates within 24 hours of the first administration on intrathecal opiates creates significant risk for the patient developing fatal respiratory depression. Patients who have had intrathecal morphine needing supplementary opiates require closer nursing care and special monitoring. There is no reliable minute to minute CO₂ monitor for non-intubated patients. Respiratory rate measurements correlate poorly with breath tidal volume size. Pulse oximeter readings can be normal in the presence of severe respiratory depression and when the arterial CO is up to 80mmHg. These pulse oximetry limitations must be realized. Naloxone for injection must be attached to the patient's bed at all times for immediate availability. This heightened patient care is not needed if only non-opiate rescue analgesia is to be administered.
- There is a 60% incidence of severe nausea for up to 24 hours duration. Opiate induced nausea associated with other routes of administration is of short duration and repeat opiate doses can be titrated downwards to avoid recurring nausea. Intra-theal opiate induced nausea is sustained and not downwards titratable.
- There is a 60% incidence of severe pruritus for up to 24 hours duration. Opiates administered by other routes can produce pruritus, but for shorter duration and less severe.
- Extensive research has not found a safe intrathecal dose that still has analgesia efficacy for the majority of the patients. Pruritus is a side effect even low doses cannot eliminate.
- The amount of opiate drug saved using intrathecal morphine over non-intrathecal morphine is miniscule, as morphine is very cheap. One estimate was it save \$3 per patient in morphine costs.

SUMMARY; Intrathecal morphine achieves higher CNS morphine concentrations than peripheral morphine administration. Intrathecal morphine patients require upgraded nursing care and added monitoring if rescue opiates are administered.

The biggest cause of failed spinal anesthesia is inappropriate use of hyperbaric (heavy) local anesthetic solutions. Hyperbaric solutions are good for cesarean sections where the weight of the drug drifts in to T6 and higher, following L3-4-5 level injection in the cerebrospinal fluid to make an abdominal surgery possible. For knee surgery the drug has to remain exactly in the mid lumbar region where the intrathecal injection was done. A hyperbaric solution takes drug away from L3-5 causing a slower onset of nerve block in the surgical dermatomes and shorter duration block. So rather use ISOBARIC DRUG (without dextrose) for TKR spinal blocks.

Drug choice is critical too.

- Use of 0.75% Ropivacaine (approved in Europe for spinal use) results in very fast onset block but it only last 2 ½ hours. The surgeon has to be fast too. Urine catheters may be omitted if the bladder is emptied immediately pre-anesthesia and IV fluids are slightly restricted. The bladder is normal by about 3 hours after surgery



- Use of 0.5% bupivacaine produces surgical block of 3 hours but onset can be slow and take longer than 30 minutes to develop the first sign of a block.
- The ideal drug is 0.75% bupivacaine which generally gives a fast onset block, and a surgical block of 3 ½ hours duration. Note bladder paresis may however last 6-7 hours so all patients must be catheterized.
- The only drug additive that is good and also highly recommended is Fentanyl 25 to 50 microgram. Fifty µg is best. The main benefit of fentanyl is it changes the pharmacetics of the solution by slightly alkalinizing it. This increases the unionized fraction of local anesthetic drug making the solution behave as if it were 25% - 50% more concentrated. This very noticeably accelerates the onset of the nerve block. The opiate effect might also offset any patient discomfort if the surgeon makes an incision before the block is well developed.

There is of course no regional anesthesia effect from shortly after the surgery, so other regional anesthesia should also be given to the patient, such as peripheral nerve blocks. Continuous post-operative spinal anesthesia is not recommended due to its neurotoxic effects. Many surgeons favor injecting their own Peri-Articular Infiltration (PIA or LIA) at the end of surgery.

B. Epidural anesthesia.

The big attraction to epidural anesthesia is the ability to maintain local anesthetic analgesia by continuous epidural infusion into the post-operative period for any duration chosen. There is a one in 150 000 risks of paraplegia developing. Paraplegia can be argued to be a more burdensome problem than patient death, if not as bad. Much of the anesthesia practices for TKR are "cultural" and institutional habits. Some centers have used epidural extensively and sent their staff around the world lecturing the religion of epidural anesthesia for major leg arthroplasty. The world was not converted, and most centers retained their own different culture of anesthesia choice for TKR patients.

Epidural block is however acceptable practice for TKR patients.

C. Surgeon Administered Local Anesthetic Infiltration (SALI).

This has become exceedingly popular amongst arthroplasty surgeons. It is called Local Anesthesia Infiltration (LIA), or Periarticular Infiltration Analgesia (PIA), or Peri-Articular Infiltration (PAI). It is popularly supplemented with the adductor canal block injected by the anesthesiologist using an ultrasound.

HOW IS PERIARTICULAR INFILTRATION DONE?

The most popular periarticular mixtures contain Ropivacaine 400 mg, 30 mg ketorolac, 5 mg morphine, and adrenaline (epinephrine) is mixed and diluted to 100ml with saline. Steroids and antibiotics may be added too. The surgeon injects the mixture into the periarticular tissues at the posterior, anterior, medial, and lateral tissues about the knee, as well into the skin incisions. This is done at the conclusion of the surgery.

THE EVIDENCE OF BENEFIT OF PERIARTICULAR INFILTRATION (PIA) ^{3 4 5 6 7 8 9 10 11 12}.

A number of scientific papers describe the periarticular block. Most studies have low scientific quality. Some evidence of analgesic effect is observed when the periarticular block is compared to no injection or injection of saline. This is an expected local anesthetic effect. There is no evidence that the additive drugs to the periarticular concoctions achieve better effect injected into the periarticular tissues, than conventionally injected into a peripheral vein. No evidence suggests that periarticular is the best site for LA injection.

Periarticular infiltration like all tissue infiltration blocks has a short duration of effect, namely under 6 hours from the time of injection. The analgesia is variable with some individuals achieving zero measurable pain relief. Very few individuals are completely pain free. Another big limitation of SALI is that it is only injected at the end of surgery, and if the patient is receiving general anesthesia it will be deep anesthesia, with its own limitations. When comprehensive nerve blocks are administered before surgery the patient gets the benefit of being given a very light anesthetic and they achieve a very fast initial wake up and all the benefits of the regional anesthetic, as would be obtained had they had awake surgery.



Some studies have compared performing just the posterior part of the periarticular block to the sciatic nerve block. The sciatic nerve block group achieved slightly better posterior analgesia. That suggests a surgeon could substitute a posterior peri-articular infiltration for a sciatic nerve block if there was some special concern about performing a sciatic nerve block. Those patients would then still need a femoral and an obturator nerve block for the rest of the pain. The posterior periarticular block however has been associated with a common peroneal nerve block developing in 20% of cases, and DVT perhaps from a vein injury and arterial wall injury with bleeding.

At the University of Iowa if a surgeon injects a periarticular mixture into the knee joint that includes opiates the anesthesia provider injects no long acting opiates at all at the end of the case. A situation cannot exist where two opposing medical specialties are both administering opiates into one unconscious patient. In our experience about 30 to 50% of these periarticular block patients then need substantial rescue analgesia in the first hour after surgery when they are awake.

The adductor canal block is popularly requested by surgeons to supplement the incomplete periarticular infiltration block on the vastus medialis muscle which is incised with the surgical approach.

WHAT IS THE ADDUCTOR CANAL BLOCK?

It is an injection of the saphenous nerve and the nerve to the Vastus medialis muscle within Hunter's canal in mid-thigh. The two nerves lie deep to the sartorius muscle in mid-thigh and lateral to the femoral artery within Hunters canal (Adductor canal). The anesthesiologist performs it under ultrasound imaging guidance. The block partially and briefly relieves some of the medial residual pain for 4 to 6 hours that escaped relief from the periarticular infiltration. If an adductor canal block is used it ideally should be repeated once or twice about 6 to 12 hours apart.

D. FEMORAL NERVE BLOCK. This nerve block supplies sensation to the greatest portion of the knee involved in Total Knee Replacement (TKR). It includes to full femur bone and the medial 50% of the tibial condyles. The sciatic nerve supplies sensation to the other half of the tibial condyles. If the nerve block volume is small, 10 to 20 ml, there is rarely an additional obturator block. However, if a large volume femoral nerve block is injected using 40 milliliters of local anesthetic then a bonus obturator block occurs in 80% of patients. If this is combined with comprehensive primary anesthetic such a general anesthetic or a neuraxial anesthetic the 20% of patients experiencing profound medial side of knee pain in the immediate post-surgery period can either be given supplementary opiates, or a supplementary specific obturator nerve block.

If the knee surgery is going to be performed awake and purely under peripheral nerve blocks then the femoral block is best injected with small volume of 20 ml local anesthetic, and the obturator nerve injected separately with a drug volume of 10 to 15 milliliters. That will assure nearly 100% block success. A sciatic nerve block must obviously also be included.

Do peripheral nerve blocks cause patients to fall after knee surgery?

When a patient falls after a knee surgery, it often results in injury to the head and even the knee. It is however presumptive that prior injection of a femoral nerve block would result in a patient falling after knee surgery. A recent 200 000 patient study by Memtsoudis, indicate that there is no correlation in patient falls after knee surgery and whether a femoral nerve block was done or not.

Falls did however increase when;

1. Patients had increased number of co-morbid diseases,
2. Patients were aged,
3. Patients were males.

It seems males are less likely than females to call a nurse for assistance when they needed to leave the bed, for a restroom visit. The biggest factor causing falls is reflex quadriceps muscle contraction inhibition resulting from shooting knee pain.

Therefore, forfeiting femoral nerve blocks in favor of periarticular infiltration to prevent falls is a wasted action.



- E. **OBTURATOR NERVE BLOCK.** This important nerve supplies the medial side of the knee joint capsule. It is responsible for 10% of post-surgical opiate usage by patients on a PCA. The obturator nerve block may be blocked peripherally in three ways;
- 1) The Psoas compartment block includes the obturator nerve.
 - 2) With the femoral nerve block using a large drug volume. This is part of the mythical and unreliable three-in-one block. Less than 70% of these patients given a believed three-in-one block will show evidence of obturator nerve block.
 - 3) As a separate and specific nerve block distal to the joint crease. Blocking the obturator nerve is easily done using either pure nerve electro-stimulation guidance. The best technique utilizes a combined ultrasound, and electrostimulation guidance technique.
- F. **SCIATIC NERVE BLOCK.** The sciatic nerve conveys about 30% of the pain that patients experience after TKR. That pain is dominantly posterior to the knee but also in the upper tibia lateral half. Although receiving a sciatic nerve block, together with femoral nerve and an obturator nerve block is critical to achieving 100% post TKR analgesia, it became fashionable for many surgeons to insist the sciatic nerve be omitted from the TKR patient care in the last 15 years. The reason for that is, that the surgery itself frequently injures the sciatic nerve. A TKR for degenerative arthritic knee has a 1 in 2000 chance of injuring the sciatic nerve. A TKR surgery for a rheumatoid inflammatory knee has 1 in 600 chances for injuring the sciatic nerve. The chance of nerve block injuring the sciatic nerve is much better than 1 in 10 000 cases. Surgeons fear the nerve block injures the sciatic nerve and the surgery gets blamed for it. The fact is nerve block will not injure the nerve in three life times of surgery for a surgeon, whilst the surgery will injure about 2 to 4 patients of a busy arthroplasty surgeon within one career life time. That omission of the sciatic nerve block increases the pain a vast number of patients who were not going to ever get an injury.
- Which sciatic nerve block should be done?**
- Although popliteal fossa sciatic nerve blocks have been reported as having been done and with some observable benefit, it is standard and rational practice to do the nerve block more proximal to that. Staying away from a surgical field where surgical sterility is MAJOR PRIORITY is sufficient reason to avoid doing a popliteal sciatic nerve block. If the block is performed at the level of the GT-IT line (Greater Trochanter - Ischial Tuberosity), or more proximal the following important nerves will be included in the nerve block. They are the nerve to the hamstrings and the posterior cutaneous nerve of the thigh (PCNT). PCNT is not needed for routine TKR but is needed for surgeries like a trans-knee amputation. The hamstring muscles carry some knee sensation fibers to the lateral condyle of the tibia.
- G. **LATERAL CUTANEOUS NERVE OF THE THIGH (LCNT).** Knee surgery incisions very rarely, and never with common surgeries encroach into this nerve's dermatomal region on the lateral aspect of the knee. Having it nerve blocked, does help the patient tolerate the ischemic discomfort from a thigh tourniquet if the patient is fully awake. That tourniquet discomfort can be handle by general anesthesia or very deep sedation. The nerve is very easily blocked with an ultrasound guided nerve block just below the inguinal ligament. The nerve is also blocked with psoas compartment block.
- H. **INTRA-ARTICULAR LOCAL ANESTHETIC.** This should never be used for surgeries not removing all of the knee cartilage because intra-articular local anesthetic damages joint cartilage surfaces. Conversely it could conceptually be used after a total knee arthroplasty where all cartilage is removed. It however then has too miniscule of an analgesia effect to be worth using. The bone, muscle and skin incisions are largely not anesthetized.
- I. **LIPOSOMAL BUPICACAINE KNEE INFILTRATION AFTER TKA.** This is done by the surgeon. This has had limited studies. Some modest efficacy versus no injection has been shown. So, it performs better than placebo. Studies versus best regional anesthesia studies have not been done yet. It is



very expensive. It is very heavily marketed by the drug company. One has to question bias of the authors in the early studies, which are few done prospectively. The benefit does not validate the cost not the omission of more efficacious nerve blocks. It has been thought that the sustained slow release of liposomal bupivacaine could substitute for a perineural catheter in sustaining nerve block. The big draw-back is that the release of the bupivacaine results in too low of a perineural local anesthetic concentration to establish the high-grade block needed immediately with the surgery. The best use of this drug would be as last top-up injection via a perineural catheter before removal of the catheter. That would still have to be balanced against its very large cost. Slow release liposomal local anesthetics solutions have been assessed for thirty years now and it is an old concept still trying to work.

J. NOVEL NERVE BLOCKS FOR THE POSTERIOR JOINT CAPSULE.

The classic and proven efficacious nerve block for the posterior aspects of the distal femur bone cuts, the posterior joint capsule and the posterior tibial proximal head cuts is sciatic nerve block. The more recent attempt at designing a different way of applying local anesthetic to relieve posterior pain following knee arthroplasty is a selective capsule infiltration limited to the posterior capsule. That is injected from anterior at the end of surgery but the depth to which the needle is inserted is blindly assessed. There have been cases where the vasculature has been injured with this injection one ending in lower leg amputation. Mahadevan's study strongly suggests the infiltration technique is very inferior to the analgesia efficacy of a sciatic nerve block after knee arthroplasty in the first post-operative twelve hours¹³. That observation is not validated however.

More recently that posterior infiltration technique has been improved in terms of safety. Two unrelated workers directed a needle under ultrasound guidance into the space between popliteal blood vessels and femur. They then injected a large volume of local anesthetic there. One was Clint Elliot in 2015, calling the technique *IPACK*¹⁴. The other was Runge who calls the block, perhaps more correctly, the *popliteal plexus block*¹⁵. The initial clinical studies reveal this block produces some degree of analgesia generally, but not evenly across subjects. Evidence, although not fully studied did not show sciatic nerve weakness in the lower leg in this small group. The merits and place of this block need to be determined.

Another nerve block variant, called the **femoral triangle block**, was described by Runge in 2016¹⁶. It is injected 10 centimeters distal to the inguinal ligament, ultrasound guided, with needle passing through the sartorius muscle and directed to touch the antero-lateral angle of the femoral artery. At that point the saphenous, the nerve to vastus medialis and medial cutaneous nerves are blocked. They are all terminal branches of the femoral nerve. In effect it is a very proximal adductor canal block which is more commonly done in the more distal mid-thigh region. Some American colleagues have anecdotally reported intentionally doing "proximal" adductor canal block in attempts to win some drug spread onto the femoral nerve in order to improve the analgesia effects of the block. This technique modification is reportedly done without surgeon knowledge, who had prohibited a femoral block being performed. The anesthesiologist anecdotally reports the more proximal adductor canal block, effectively a femoral triangle block, has improved analgesia features over the adductor canal block when performed more distally. This concept of nerve block has not yet found any popularity and is totally understudied.

Analgesia efficacy of Peripheral nerve blocks for post knee arthroplasty pain.

A standard volume (5 to 20 ml) femoral nerve block reduces post-surgical pain by 60%. Addition of an obturator nerve block for the medial pain reduces the pain by a 10%. When a femoral nerve block is injected with large volume (40 ml) the drug can spread proximal to where the obturator nerve exits the psoas muscle. Two nerves are blocked then with a single injection and pain is reduced 70%. Addition of a sciatic block for the posterior pain reduces pain an additional 30%. Patient have 100% analgesia after receiving a femoral nerve, an obturator nerve, and a sciatic nerve. The posterior pain is only severe for a short period of 4 to 8 hours and a single shot sciatic block is sufficient. The major and most long-lasting pain falls into the distribution of the femoral nerve and a femoral nerve catheter LA infusion can prolong analgesia for 24 to 48 hours after surgery. Mayo clinic data showed that



adding peripheral nerve blocks to their knee arthroplasty patient care added a zero incidence of nerve injury to their baseline surgery associated nerve injuries. The Mayo study spanned decades of experience is very credible.

The chief benefits of using peripheral nerve blocks are;

- i. Nerve blocks are capable of producing profound and total analgesia.
- ii. The nerve block is easily extended with perineural catheter local anesthetic infusions.
- iii. Nerve blocks reduce opiate requirements. Opiate avoidance has big medical benefits.

CONCLUDING COMMENTS

Who chooses the regional anesthesia technique that is best for arthroplasty patients in general and for any one patient in particular?

This is a large part of the dilemmas in this debate. In very many healthcare systems in the world anesthesia providers have little or no say and the surgeon dictates whether regional anesthesia of any form is used, or not all. Also, the surgeon often prescribes the rest of the analgesia plan.

The future solution lies in;

- Reporting up in the scientific literature of all bad case events linked to specific knee arthroplasty regional anesthesia techniques. This evidence must be for all to see.
- Reporting of retrospective analyses of knee arthroplasty patient group outcomes correlated with regional anesthesia technique. Of special interest is the incidence of persistent post-surgical pain (PPP) at 6 months after surgery.
- Perform prospective comparative studies comparing outcomes and analgesia effects between the best multi-block regional anesthesia technique (femoral nerve catheter and sciatic nerve single shot block) with periarticular block and adductor canal block. Enough efficacy studies have been done but insufficient comparative studies between PIA and best other regional anesthesia techniques have been done. The few such studies done thus far, mostly suggest PIA is substantially inferior to peripheral nerve blocks for analgesia effects.
- Engage orthopedic surgeons more in scientific dialogue at their conferences and at our conferences. We need joint lecture sessions. Best patient care has to be the common goal. Practice should be based on scientific evidence not arbitrary assumptions.

CONCLUSION

There is an unfortunate medical trend to promote new analgesia techniques as if they are major scientific breakthroughs when they have only passed the efficacy study phase. That alone gives no indication whether it is better than established best techniques. It is clear that there is currently no universal and joint anesthesiology and surgical agreement on what the best regional anesthesia for knee arthroplasty patients is.

This author predicts the trend will swing back peripheral nerve blocks performed by anesthesiologist will become the stand of practice for major joint surgery of the leg, but this will likely take ten years. The biggest limitations in local anesthetic techniques that require drug to spread away from the point of injection to reach a target nerve are (i) that drug spread is inconsistent amongst different individuals, and (ii) a motor nerve stimulation cannot be used as the ultimate marker of precision needle tip placement. The difference in between a needle being on one side of a fascia or the other can be a single millimeter. That can dramatically alter drug spread. Although the use of ultrasound guidance has been a dramatic advance in the practice of regional anesthesia it is crude instrument. Ultrasound guidance can be a very substantial indicator of needle tip position in an expert's hands viewing large superficial nerves. Less than expert practitioners may not recognize the phenomenon of needle cut-off and be mistaken about their perception where the needle tip is. Furthermore, many targets lie in deep positions and many patients may have aged sonographically opaque skin or be severely obese. In that situation, a needle tip



can easily be placed on the wrong side of fascia prior to injecting drug. Lastly the sonographic visualization of drug spread equally is crude and no guarantor of the drug reaching distant target many minutes later. Studies of infiltration blocks and fascial plane blocks may show group average positive success rates, but 4 to 40% of patients, or even more, may not achieve the full desired benefit. That represents a 100% failure for that individual patient. We do not practice medicine based on grouped therapy and averages. We only study it that manner. We practice medicine on one individual patient at a time and the only goal can be perfection in what we do for that one patient at a time, every time.

I predict a return to specific targeted nerve blocks where nerve stimulation verification of ultrasound guidance is feasible, and where virtual 100% analgesia success rates are achievable.

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 Career outline;

- Born in South Africa.
- Studied for eight years before entering general medical practice.
- Spent seven years in rural family medicine; delivered babies, did caesarean sections, worked in the emergency room, did anesthesia, and did minor surgery.
- Studied anesthesia for 4 years.
- Worked as a specialist anesthesiology for 14 years in private practice, in a metropolis of 7 million people. Covered all fields including neurosurgery, neonatal and pediatric surgery, vascular surgery, orthopedic surgery, and had an extensive sedation practice.
- Work 14 years in academic anesthesia at the University of Iowa.
 - Professor of Anesthesia.
- Special interest fields; (i) medico-legal expert in malpractice cases, (ii) regional anesthesia and acute pain control, (iii) lecturing and teaching anesthesiology.
 - Dr. Raw remains however a generalist at heart with interest in all aspects of anesthesiology.
- Countries lectured or presented in: South Africa, Zimbabwe, Kenya, Canada, Sri Lanka (2x), United Arab Emirates, USA, England, Italy, Jordan (3x), and Mexico.

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