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An Update on Regional Anesthesia Blocks for Hip Surgeries

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OBJECTIVE; after attending this lecture and studying the material the learner will be able to evaluate the merits and demerits of traditional and recent trends in regional anesthesia techniques for hip surgeries. The learner will be able to integrate the recommended regional anesthesia techniques into the primary anesthetic plan for the surgery and also into the post surgical analgesia plan. Also, this lecture will have the goal of providing best patient care, with best patient outcomes. The learner will have understanding of the various surgical approaches and how they influence post surgical pain.
CONFLICTS; the teacher has no academic financial conflicts.

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1. INTRODUCTION

Anesthesia for Hip surgeries is important for the following reasons;

- Hip Arthroplasty is associated with severe to moderate-severe post-surgical pain.
- Hip Arthroplasty is a very common surgery.
  - About 1 million hip arthroplasties are done annually in the world half of which are done in the USA.
- The annual number of hip surgeries performed increases annually.
- Major joint arthroplasty patients have a high risk for developing chronic pain syndromes[1],[2].
- Arthroplasty surgery is a large part of anesthesia providers future because;
  - There is no imaginable prospect of a medical cure for degenerative or inflammatory major joint disease.
  - The world population is living longer with increasing the numbers of aged patients with major joint disease.

- The world population at large, is becoming increasingly obese and this accelerates major joint disease.
- Pain is the leading cause of patient dissatisfaction after surgery.

There was a steady trend over the last thirty years to utilize more and more peripheral nerve blocks in the anesthesia and analgesia plans of major joint arthroplasty. That trend has reversed in the last 5 years, with a hard-pressed priority to discharge patients sooner in order to maximize hospital profits. Nerve blocks are being substituted by surgeons injecting infiltration blocks. The surgeons believe this will facilitate earlier hospital discharge, assumed to be better for the patient, but primarily designed to allow swifter re-use of surgical beds and book operating rooms more intensely to increase hospital and surgeon profits.

No anesthesia provider can afford not to be expert in managing the analgesia plan and anesthetic plan for hip arthroplasty. The regional anesthesia of the hip joints is complicated in that, unlike the upper limb, complete anesthesia is not achievable from a single peripheral block injection. Complete analgesia for hip arthroplasty always requires multiple peripheral nerve injections. Commonly, incomplete nerve blocks are performed even though this is not ideal, and the patients still need much other supplementary analgesia. They are however better off, for at least partly reducing their opiate needs.

The combined THR serious complication and mortality rate is 1 to 2%[3]. Anesthesia-analgesia management has a large potential to favorably influence that morbidity and mortality.

There is no accepted universal Gold Standard for pain management after knee arthroplasty[4]. There are however very good and proven principals on which to design and propose a gold standard. The first idealized clinical goal must be the complete elimination of post-arthroplasty pain and the elimination of all opiates (or maximum reduction)[4]. It is certainly achievable with the right post-surgical analgesia plan that maximizes use of regional anesthesia, and supplements the plan with multimodal analgesia. Institutions, such as the Mayo Clinic, that adopted these goals 30 years ago, reduced major arthroplasty adverse events and improved outcomes significantly, by reducing opioid exclusive-dependent analgesia regimes[5]. The second clinical goal must be to reduce the incidence of chronic pain after arthroplasty.

One additional problem in arthroplasty anesthesia is that the surgeons specialized in that sub-field tend to be much more prescriptive about anesthesia than all other fields of anesthesia. In the USA one survey showed the basic anesthetic outline is prescribed in 48% of institutions or surgical groups, by the surgeon. This severely limits advancement of anesthesia for knee and hip arthroplasty surgery as surgeons are not anesthesiologists. Anesthesiologists know anesthesia best. A surgeon should ideally only communicate his/her operative-condition needs, and relevant individual patient unique surgical or medical considerations. The anesthesia provider should primarily formulate the best patient individualized plan, in communication with the surgeon, as needed. Arthroplasty anesthesia providers, and the involved surgeons need to work closely as a team, with mutual respect and mutual understanding.

The major categories of hip surgery are;

1. Hip arthroplasty for degenerative joint disease.
2. Geriatric hip fractures.
3. Juvenile periacetabular osteotomy for congenital hip dysplasia.
4. Major trauma involving the hip.
5. Hip arthroscopy
6. Other

This lecture will focus heavily on hip arthroplasty, and will only lightly discuss geriatric hip fractures, and juvenile acetabular osteotomy. The lecture will not discuss other hip surgeries and procedures.

2. THE UNIQUE PATIENT PAIN PROBLEMS, AFTER HIP ARTHROPLASTY[1]

Pain after hip and knee surgery is important to treat well because it typically ranges from moderate-severe pain to severe pain. In addition, a large fraction of these patients will not return to zero pain states after the surgery. Persistent Post-surgical Pain (PPP) is still present in up to 15% of patients at two months after surgery[6]. Chronic pain is pain that is still present at 6 months after surgery in up to 10% of patients. One percent of these patients will have complex regional pain syndrome (CRPS) at 6 months after surgery[7].

Good pain data is hard to obtain on arthroplasty patients because orthopedic surgeons usually report their surgical data as series averages using functional scoring systems that bury pain scores in combined totals, weighted towards movement ranges and function[8],[9],[10],[11],[12]. Popular scoring systems are the WOMAC, HHS, HAGOS, and FJS-12. They combine parameters indirectly reflecting flexibility, strength, functionality with pain scoring. The objective of the scoring system was to assess different surgical approaches and different patented prosthetic designs. It is impossible to separate out pain scores to assess anesthesia and analgesia therapies effects on the pathological post-surgical pains that patients experience. In addition, they avoid reporting the subgroup incidences of patients with "bad scores" in favor of only reporting the group score[13,14]. This facilitates the ranking of different surgeons or institutions or product designs, but handicaps measuring the effects of different analgesia and anesthesia interventions on pain outcomes.

These scoring systems, are usually licensed and copyrighted and not usable by non-orthopedic society members. Most of these scoring systems are not well scientifically validated. They also have no clear definition of what can be considered a good outcome of the surgery, let alone a measure of pain improvement after surgery. This makes the simple study of pain after arthroplasty surgery very difficult. This has been criticized[8]. These systems are too surgeon based and have too little patient input. This is a bias thus favoring a surgeon's good reporting of "operating results".

There is no reason to believe that hip arthroplasty patients will differ in their responses to perioperative analgesia therapies from any other class of patient. The foremost unique thing about arthroplasty patients, compared to non-orthopedic surgery patients is that the arthroplasty patients' prime indication for surgery is pain, and that it is confirmed a very large fraction of them have significant pain long after surgery. There is every reason to believe that logical scientifically based peri-operative anesthesia and analgesia coordinated plans can contribute significantly to reducing acute and long-term pain after arthroplasty. There is also evidence that the wrong perioperative analgesia plan could worsen PPP after arthroplasty. Primarily this would be spinal anesthesia with water soluble opiates.

There is a current trend to do ambulatory surgery and fast track surgery for hip and knee arthroplasty. The definition of Ambulatory surgery in the USA, for billing purposes, includes staying one night in hospital but being discharged at 23 hours after surgery. The driving force behind this trend is economic. The goal is to save in-hospital costs for the hospital, and improve profitability by maximizing turnover in surgical beds and operating rooms. There may be significant added costs to family members needing to stay at home to nurse the patient. Part of this trend includes the promotion of "minimally invasive arthroplasty surgery". Minimally invasive arthroplasty surgery is simply the use of a skin incision that is 30 to 50% shorter than a standard incision. Minimally invasive arthroplasty

surgery is technically much harder to perform and requires proprietary modified orthopedic tools and devices which are highly promoted by the device companies. Patient benefits are not yet proven. Regardless, this trend increases the need to provide high grade postoperative analgesia to patients beyond discharge from hospital and there are many challenges in this regard.

One study into why patients failed to achieve hospital discharge at 24 or 48 hours after hip and knee arthroplasty showed ***pain was the prime cause*** followed by dizziness and general weakness, then followed by nausea, vomiting, confusion, sedation and need for blood transfusion[15]. Clearly opiates played a role in nausea vomiting sedation and confusion. This all emphases the need for more use of regional anesthesia and less opiates.

2.1 THE MECHANISMS WHEREBY ACUTE SURGICAL PAIN BECOMES A CHRONIC PAIN COMPLICATION[16]

It is well understood how surgery with acute tissue damage causes acute pain. The process starts with transduction of the tissue injury into peripheral nerve signals, that gets transmitted to the brain via serial connected neurons. Acute pain resolves quickly due to (1) the cessation of the tissue damage, and (2) due to tissue healing. Analgesia typically only needs to be provided briefly during this natural pain resolving process, in normal situations.

There are however natural mechanisms that briefly perpetuate the duration of pain signals beyond the initial injury and that also amplify the intensity of pain signals. Those mechanisms involve peripheral sensitization and central sensitization. They are life protective mechanisms in nature, that terminate with the healing process. Failure of these pain signal perpetuating and amplifying mechanisms to terminate in human healthcare is pathological. Anesthesia and analgesia management greatly influences these events.

It is a special clinical problem when Persistent Post-surgical Pain (PPP) and chronic pain arises after surgery. The primary reason patients undergo joint arthroplasty is because they had pain prior to surgery and this makes PPP and chronic pain even more likely events, than after non-orthopedic surgery. Mechanisms that cause PPP and chronic pain include genetic variations of sodium channel receptors, substance-P mechanisms, and protein structures. There is altered NMDA receptor function, loss of inhibitory effects on dorsal root neurons, increased activation of spinal and peripheral glial cells, increases in central and peripheral cytokine activity (e.g. IL-6), peripheral and central prostaglandin alterations, neural growth factor alterations, and prostaglandin production changes. There is a plethora of neurotransmitters involved in pain regulation and the same neurotransmitter may function at different sites and have different effects at each site. Some pain associated neurotransmitters include serotonin and GABA. Some ion channels are involved such as voltage gated sodium channels, and voltage gated calcium channels. This is an area of intense scientific research, but to date very little has translated into daily clinical utility therapies.

Clearly, pain physiology is very complex, and there is a blur between inflammatory pain and neuropathic pain. For the clinician, little of the science referred to above merits a detailed discussion. There is however, fortunately much that is of practical use, still to discuss.

2.2 THE PREVENTION OF CHRONIC PAIN AFTER HIP ARTHROPLASTY

Up to 60% of patients may not be fully pain free at 6 months after surgery[1]. The risk factors for chronic pain after surgery are; (i) use of opioids before surgery, (ii) extensive tissue destruction by surgery, (iii) surgical injury to small nerve branches, (iv) inflammatory processes associated with the arthritis conditions, and (v) woman have higher risk for developing chronic pain syndromes.

The principle remedies to treat and prevent chronic pain syndromes after knee and hip arthroplasty are;

(1) Pre-emptive analgesia,
(2) Regional anesthesia,
(3) Multi-modal analgesia,
(4) Anti-hyperalgesia drugs,
(5) Opioid avoidance.

Opioids may be used as rescue analgesia when other analgesia modalities are insufficient. When opioids are used, they should be used as late as possible, only when needed, and for as short a duration as possible. That will maximize their efficacy when used.

(1) PRE-EMPTIVE ANALGESIA;

This means establishing working blood concentrations of drugs that favorably influence peripheral and central nerve sensitization before tissue injury occurs. It excludes using opiates. The principle pre-emptive analgesia drugs are acetaminophen and NSAIDs (and COX II inhibitors) and small dose Ketamine.

(2) REGIONAL ANESTHESIA;

Regional anesthesia as primary anesthetic compared to general anesthesia has strong suggestive evidence of preserving immunity in the patient. This has been shown with better survival after cancer surgery and reduced surgical infections after arthroplasty surgery[17]. The explanation may lie with the fact the fact that local anesthetics have some antibacterial effects, and also that the stress responses is dampened by use of regional anesthesia. It is also believed combined regional anesthesia with general anesthesia will also have this benefit over pure general anesthesia. Preserved immunity will correlate with reduced surgical infections. The benefits of regional anesthesia versus general anesthesia has been globally reviewed by Roger's[18]. They strongly suggested there was reduced respiratory complications, reduced mortality, reduced incidence of DVT, reduced incidence of cardiovascular complications, and reduced incidence of post-operative cognitive dysfunction associated with the use of regional anesthesia. It has also been shown that when regional anesthesia is combined with general anesthesia, the benefits that are attributable to regional anesthesia alone still occur.

(3) MULTIMODAL ANALGESIA;

Multimodal analgesia has two main goals[19,20];

1. **Treat pain maximally** by combing different classes of analgesia agents gaining their synergistic analgesia effects, but also moderating the different dose-related side-effects of the different drugs. Do not combine drugs within a class, as the side effects will be dangerously additive.

2. **Eliminate or reduce the need for opiates**. This includes shortening the period that opiates are used. The intrathecal injection of large CNS doses of long acting opiates or the epidural injection of slow release opiate preparations is contrary to these goals.

Not all current authors-teachers understand that multimodal analgesia includes the concept of opiate avoidance, as Hendrick Kehlet the father and prophet of the concept multimodal analgesia advises. For example, a recent review on Multimodal analgesia by Young and Buvanendran they wrote at emphatic length about ways to administer opiates to these patients[21]. Kehlet's teaching is well founded in the science on the detrimental effects of opiates inducing hyperalgesia and long-term pain. Other authors on multimodal analgesia recognize Kehlet's teachings[22]. Basic multimodal drugs are (i) acetaminophen, and (ii) NSAIDs and COX2Is. Short duration courses of NSAIDS and COX2Is do not increase risk of cardiovascular disease nor delayed bone healing[23]. Gabapentin has some modest benefit in selected patients already manifesting chronic pain syndromes or allodynia before surgery.

(4) ANTI-HYPERALGESIA DRUGS.

Practically there is only one drug. It is small dose ketamine[24]. Small dose is 50mg for average adults or 0.5mg/kg for others. That dose provides about 5 to 10 minutes acute pain analgesia. That is however not a problem. The prime benefit of low dose ketamine is its sustained anti-hyperalgesia effects. Ketamine is a non-competitive antagonist of the NMDA receptor. The NMDA receptor is the main end-point for all factors that sensitize for pain, that amplify pain, that cause hyperalgesia and that cause opiate tolerance. Small dose ketamine binds the NMDA receptor for about 24 hours and acutely and immediately reverses both chronic and acute opiate tolerance and hyperalgesia. It hardly matters that basic science researchers can demonstrate so many different factors involved in pathological pain. All those factors seem to ultimately influence the NMDA receptor and ketamine is a near perfect drug acting on the NMDA receptor. Ketamine should be used routine for arthroplasty patients.

Gabapentin also has an anti-hyperalgesia effect, of modest magnitude. It could be used selectively in patients who have pre-existing allodynia or suggestion of CRPS. It is reasonable to use Gabapentin routinely as premedication in risk patients for post-op pain syndromes.

(5). OPIATE AVOIDANCE STRATEGIES.

An opioid avoidance strategy means (i) NOT administering opioids prior to surgery if not needed, (ii) avoiding intra-operative opioids, and (iii) transitioning postoperative opioid therapy to oral non-opioid analgesics as quick as is achievable. The avoidance of opioids however must not be at the expense of having the patient suffer. Preventing severe acute pain and suffering is the biggest priority and takes precedence over opioid avoidance. Clever use of multimodal analgesia, appropriate primary anesthetic design, and maximum use of regional anesthesia will greatly facilitate opioid avoidance AND achieve maximum acute analgesia and least long-term pain.

Opioids may be used with induction to reduce the amount of primary induction agent used, and to blunt the hypertensive responses of intubation. **Opioids should be avoided during maintenance phase of**

anesthesia. Long acting Opioids that are expected to be needed after anesthesia should be commenced 30 to 60 minutes prior to the end of surgery. This will ensure they are just starting to achieve the maximum benefit for the dose of drug given just as the patient is awakening.

With neuraxial anesthesia the addition of fentanyl to the local anesthetic mixture for the purpose of accelerating onset of nerve block is reasonable. However absolutely avoid long acting water-soluble opiates. The main water-soluble opiates used in neuraxial anesthesia is morphine, and hydromorphone. The same applies to epidural anesthesia. Avoiding neuraxial use of hydrophilic opioids (morphine, hydromorphone) is the most important opioid avoidance measure. Water soluble opiates get metabolized in the brain and the metabolites get trapped intrathecal by their highly ionized nature. Those different metabolites are one, the agent of the longer duration analgesia that is caused, but importantly the other is the bad agent that induces hyperalgesia and perpetuated pain. They also cause the well known exaggerated neuraxial opiate side effects of pruritus, nausea and urinary retention.

The avoidance of opioids during the primary anesthetic prior to awakening the patient, contributes to the enhanced efficacy of the opioids when they are finally used. A saying is "*Use 'em late and then use 'em good"*. If an opioid avoidance protocol was followed prior to the first use of a hydrophilic opioid it will achieve maximum analgesia for the given dose. That is, it will then be maximally effective for a modest dose only.

The detrimental effects of opiates are;

- Opiates, in particular spinal or epidural injected opiates, up regulate NMDA receptor activity which is additive to other NMDA receptor stimulation such as pain[25].
- All neuraxial hydrophilic opiates do is give sustained side-effects with no option of titration.
- Spinal hydrophilic opiates found a very negative review by Myelen who in meta-analysis of benefits and side effects could not identify a worthy advantage to their use over conventional ways of administering opiates[26].
- There is no safe way to monitor respiratory depression with neuraxial opiates. Pulse oximeters can still register acceptable oxygen saturations at a point when significant hypercapnia is present.
- Forty percent of patients with spinal morphine will have retention of urine for over 24 hours[27].
- Spinal morphine causes a 77% incidence of pruritus[28].
- Spinal morphine causes a 1/275 (0.36%) incidence of critical respiratory depression[29].
- Direct intrathecal injection of hydrophilic opiate is not "small dose" opiate usage but large dose opiate injection direct to the CNS. Larger CNS hydrophilic opiate concentrations are achieved via intrathecal injection that what standard systemic dose of the same drug can achieve can achieve.
- Spinal morphine and other opiates have been shown to acutely induce hyperalgesia[30]. A single dose of spinal morphine induces (i) immediate analgesia lasting 3 to 5 hours followed by (ii) a late onset (after 5 hours) hyperalgesia lasting 1 to 2 days. Ketamine given

simultaneously did not alter the early morphine associated analgesia by nearly eliminated the late onset hyperalgesia[31].

- Using regular doses of fentanyl intraoperatively, doubles analgesia needs for four hours after surgery.

There are however still practitioner-experts that regard opiates as central to perioperative management despite recent scientific evidence to the opposite[32]. That is wrong.

3. GENERAL BENEFITS OF REGIONAL ANESTHESIA FOR HIP SURGERIES[33],[34].

There is much fervent opinion on this matter. The science that unequivocally proves extensive and significant benefits to using regional anesthesia in general, does not exist. That fact however does not exclude the possibility that use of regional anesthesia in orthopedic surgery in general does have these suspected benefits. With all metanalyses on this subject, conclusions either show clear benefits from using regional anesthesia, in what ever form was studied, or they show lack of benefit. The studies NEVER show HARM from using regional anesthesia. That fact makes the presumption of that there thus in truth, is more benefit to use of regional anesthesia than just providing anesthesia and post-surgical analgesia benefits. The lack of clear uncontroverted evidence of benefits lies in the methodological changes in researching the subject. This can also be phrased that, lack of clear benefit is not itself evidence of no benefit. If one adds in to consideration rational scientific thinking and extrapolates related validated facts, the argument to use more regional anesthesia in order to benefit the patient primarily, is overwhelming.

The matter has been much studied, but series are small, and studies are frequently scientifically suboptimal to answer the benefit question. There is also the major problem of exceedingly little standardization between a very diverse range of anesthesia practices. That makes doing metanalysis very difficult. Also, many anesthesiologist-written studies do not differentiate between the types of hip-surgery done, within the study groups. As bad, surgeon-written studies poorly or not at all do not differentiate between the subtypes of regional anesthesia administered to the study patients. Sometimes subarachnoid anesthesia is lumped together with psoas compartment blocks and simple femoral nerves blocks under generic collective term of “regional anesthesia”.

The final biggest problem is that orthopedic surgeons are arguably the most controlling and domineering surgical group granting the least anesthesia autonomy and permission to determine patients’ best anesthesia care. That makes standardization, and doing prospective randomized regional anesthesia studies, very difficult. Good metanalysis are equally impossible to do for the same reasons, all stated above.

That all said, there are consistent trends and strong rational logic suggesting there are extensive and diverse patient outcome benefits in performing regional anesthesia in all categories of hip surgery patients. Perhaps the biggest argument for doing regional anesthesia for patients undergoing hip surgeries, is that studies at the least, virtually NEVER suggest a trend for the patient outcomes to be worse following use of any regional anesthesia. That strongly implies the opposite. That is namely. That regional anesthesia is beneficial to patient healthcare by improving outcomes as well as providing profound analgesia. If the effects of regional anesthesia were neutral, there would not be this amazing consistent trend towards improved outcomes, even if only barely statistically provable with available data.

Elmofty in 2017, did highlight the biggest attraction to prefer non-neuraxial regional anesthesia over neuraxial blocks, is that the most serious peripheral nerve block complications pale in significance compared the paraplegia that can follow any neuraxial block. Even if paraplegia from a neuraxial hematoma is rare, it arguably is more devastating to the patient than even death. The superimposed fact that veno-thrombosis with pulmonary embolism is common enough to require aggressive prophylactic measures in all hip arthroplasty patients. Omitting neuraxial blocks allows better pharmacological thrombo-prophylaxis and a closer coordination with simultaneous peripheral nerve blocks.

The outcome-benefits of regional anesthesia for hip surgery patients, will thus be stated as follows;

- **Reduced operating room time used**. The gain in time efficiency occurs at the end of surgery. Patients who had surgery performed while awake under regional anesthesia, or had surgery performed with combined regional anesthetic and general anesthetic are fit to leave the operating most soon. That is, they are very much faster fit to transfer from the operating to the post-anesthesia care room (PACU). The gain in time even exceeds the time it takes to perform the nerve blocks in the operating room. If the nerve blocks can additionally be performed prior to the patient entering the operating rooms, then the total reduction in operating room time is the greatest. The reason is that a patient who has had solely a general anesthetic need a full deeper anesthetic to tolerate the surgery. They then take longer to recover from the deep anesthetic. Patients under general anesthesia with substantial nerve blocks, only need light anesthesia and recover highly significantly faster[33].
- **Less post-operative nausea and vomiting[35]**. This is attributed to the patients needing less opiates.
- **Reduced incidence of deep venous thrombosis and pulmonary embolism[35,36]**. Already in 1990 in arthroplasty patients, Prins was able in metanalysis, to significantly suggest that the use of regional anesthesia might on its own reduce veno-thrombosis risk by 50% compared to general anesthesia, although that was considered insufficient prophylactic therapy on its own[37]. This thrombosis preventing effect may result from three mechanisms;
    i. The patient being more comfortable after surgery will generally be more dynamic lying within the bed. The patient will be less immobilized to protect the surgical tissues from becoming painful from movement. More movement in general, prevents clots being induced by static blood flow in immobilized body parts.
    ii. The nerve block will induce arterio-dilation in the operated leg thus enhancing dynamic microvascular and venous blood flow, thus preventing blood stasis induced veno-thrombosis.
    iii. The presence of local anesthetic in the circulating blood prevents platelet aggregation on vascular membranes via a mechanism of nitric oxide formation inhibition. That effect is not measurable on a blood sample and routine laboratory tests. That local anesthetic drug effect is however, well documented in animal research.
    - There are well written safety guidelines indicating the safe time parameters for doing neuraxial block in patients who have had, or will receive pharmacological antithrombotic surgery, and clear contra-indications for neuraxial blocks in the presence of listed pharmacological therapy. Considering the catastrophe that a neuraxial hematoma is, and the

weight of case reports, following the most recent ASRA guidelines on this topic is highly recommended.

- The guidelines for performing non-neuraxial blocks (peripheral nerve blocks) have been harder to formulate due to the paucity of case reports, and sparsity of prospective studies. Initial ASRA guidelines were excessively cautious and based upon defensive medicine rather than logical and rational medicine. This author is willing, in general, to perform blocks in patients on prophylactic therapies, but not on therapeutic therapies, unless clinical contra-indications are pressing. Then the situation is one of balancing risks against risks, and decision making includes the informed patient. See the guidelines by Chelly[38]. There are a growing number of published reports on the safe use of peripheral nerve blocks in anticoagulated patients covering multiple thousands of patients[39], [40], [41],[42],[43]. This author, anecdotally and by simple recollection, also has not had a complication in a group of about 250 various peripheral nerve blocks including psoas compartment, interscalene, infraclavicular, femoral, sciatic, and ankle blocks personally performed on patients being on various pharmacologic prophylactic anticoagulation therapies.

- **Less pain and post-surgical suffering**. This is the primary outcome of using regional anesthesia. This benefit, despite being the dominant and main benefit, is taken for granted and often not even listed as an outcome benefit.
  - This German study of Donaur published in 2018 is very illustrative[44]. It used a database of the International Association for the Study of Pain (IASP). They studied 2346 knee arthroplasty cases and 2299 hip arthroplasty cases. After adjustments for confounding factors, pain was statistically significantly reduced post-surgery, in knee arthroplasty patients, and with lower opioid consumption when regional anesthesia was used. In hip arthroplasty patients, similarly studied, only opioid consumption was reduced. Nausea was not reduced in the regional anesthesia group as a whole, likely due to the intrathecal morphine that was used in many of the patients who received intrathecal (spinal) anesthesia. The study is further limited by a probable selection bias towards only studying patients viewing their medical care more favorably. The study could not assess what fraction of administered blocks failed, not the skills levels of the anesthesia providers on each case. The study also could not assess the exact peripheral were blocks used nor review the drug doses. Lastly the study dd not review any long-term outcomes, other than the pain experienced and opiates used on the first day after surgery. It is however one of the best available scientific studies in this subject area.
  - The 2017 study of Greimel included 18 000 patients, but the researchers did not randomize the patients between each anesthesia group studied[45]. They also failed to describe what constituted a regional anesthetic. Their data collection was poor, and patients were excluded if they were even absent from the ward during the single postoperative visit by the data gathering person. Their claimed that any use of regional anesthesia statistically significantly improved 1st day after surgery pain-scores, but there are many confounding factors, and the observed measured differences were absolutely clinically irrelevant. This study is so bad it should be embarrassing to the host journal.

- **Less post-operative pneumonia.** Patients who are more comfortable, less sedated by opiates, and having no opiate-induced respiratory depression or cough suppression are less prone to develop atelectasis and secretion accumulation. They thus get less post-surgical pneumonia.
- **Less late post-surgical pain syndromes like;** persistent post-surgical pain, less chronic pain, less opiate dependence, and less CRPS.
- **Earlier discharge from the PACU (post anesthesia care unit), and earlier hospital discharge[46].**
    - One poor surgeon study on the effect of enhanced recovery spanned 13 years of data collection[47]. Data was incomplete and was collected retrospectively. No details were provided as to what exact anesthesia technique was. They spoke of "shift" towards spinal anesthesia that had to not exceed four hours duration. No spinal anesthetic techniques nor drugs were described. They claimed a trend of observing that enhanced recovery decreased hospital re-admissions, but there were many confounding factors. No long-term outcome data was given other than the readmission rates to one hospital only, of those available. The study must be rejected.
    - The Gabriel study of 2016, is most enlightening in that despite reviewing over 100 000 cases it provides no scientific recommendations about choice of best anesthesia care for THA patients, in the patients' interests[48]. Most hip arthroplasty surgery is performed outside of university hospitals, in medium community hospitals. The most-sick patients tend to receive general anesthesia, possibly to assure airway control and to avoid precipitous blood pressure changes. Higher levels of training of the anesthesia provider increased the chance the patient received a neuraxial anesthetic. The study did not differentiate whether spinal or epidural anesthetics were performed, and gave no information on whether or not any peripheral nerve blocks were done. The study did significantly observe that patients who had had a neuraxial anesthetic, due to lingering neuraxial anesthesia in the recovery room (PACU) had less pain and less nausea. There are very many confounding factors to the single observation of improved PACU stay. The study also, critically failed to comment on the more important outcomes of pain and morbidity in the post hospitalization periods. Therefore, this study has zero value in determining best anesthesia practice.
    - The 2016 study of Johnson reviewed 29 studies that included 10 488 patients who had undergone hip or knee arthroplasties[49]. The sole observation of statistical significance, is that use of neuraxial anesthesia of either type was associated with a shorter patient stay in the recovery room (PACU), but with many confounding factors for that observation. No reference was made to any associated peripheral regional anesthesia which might have been also used.
    - In Hu's study they could not support nor refute claims to regional anesthesia shortening hospital stays[35.] This is likely due each study's criteria of patient fitness to be discharged is dependent on very varied definitions of fitness-for-discharge. Also, the logistics of discharging patients may prohibit patients being discharged at any random hour. That would be dependent on all the administrative staff scheduled routines, nursing scheduled routines, and patient family availability to collect the

discharged patient. In total it makes meta-analysis of the limited data on this aspect near meaningless.

- **Reduction in deep surgical infections[50].**
- **Reduced intra-operative bleeding[35].**

Some studies suggest this benefit and others fail to show it. No study suggests the opposite. The probable benefit, when it is observed, may be related to surgeries, that are performed without tourniquets, as THA, and a trend to lower blood pressures in regional anesthesia cases.

4. NERVE ANATOMY OF THE HIP REGION

4.1. The skin of the pelvis and hip region.

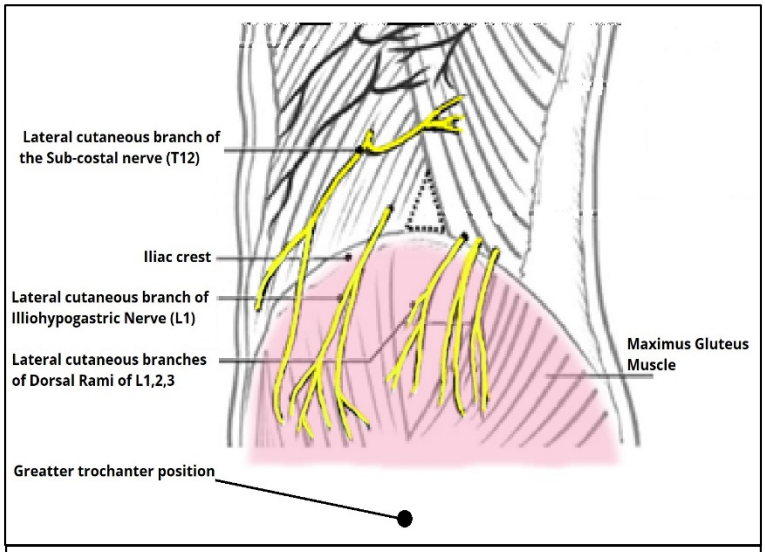


Figure #1. Skin region on the lateral aspect of the thigh, and cephalad to the skin supplied with sensation by the lateral cutaneous nerve of the thigh.

a. Upper region skin. Pelvic and hip surgery incisions may sometime extend on to and along the iliac crest, and in the thoracic dermatomes of T12. See Figures number 1. The skin immediately below the iliac crest in the mid axilla line is supplied with sensation by lateral cutaneous branches direct from Lumbar Dorsal roots of L 1 to3. Immediately anterior to that, the skin is supplied by lateral cutaneous branches of the iliohypogastric nerve (L1), and the lateral cutaneous branches of the subcostal nerve (T12). There is great variability of distribution between the nerves with any one taking over part of the usual skin area of one of the other nerves.

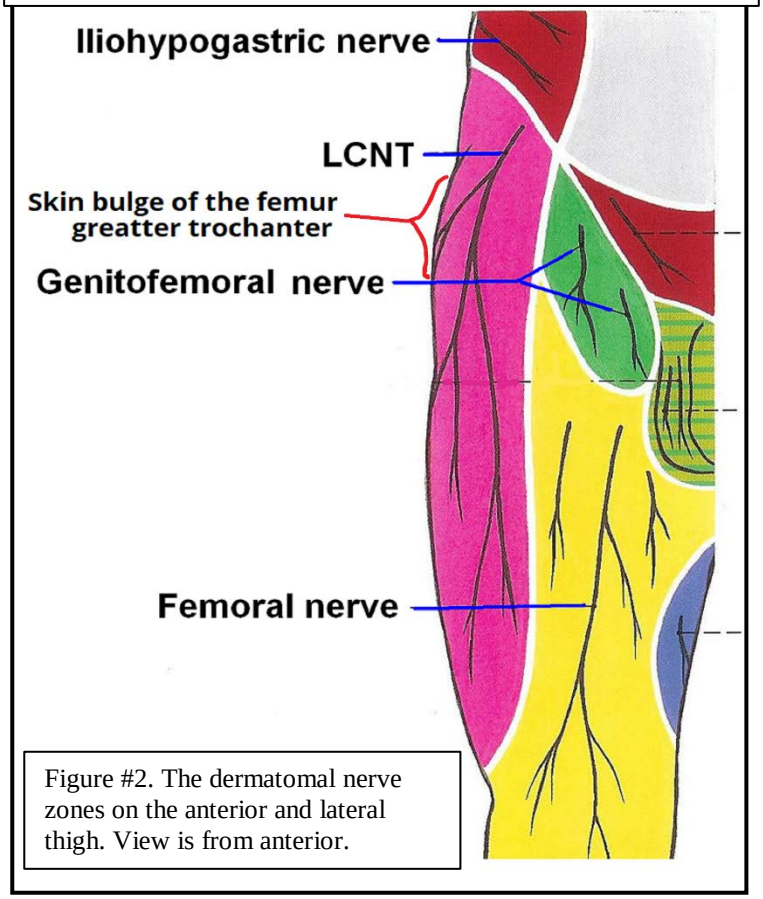


Figure #2. The dermatomal nerve zones on the anterior and lateral thigh. View is from anterior.

b. Lower region skin. See figure number 2. The skin over the greater trochanter, over which most hip surgery incisions are centered, is supplied by the lateral cutaneous nerve of the thigh. In about 5% of cases the LCNT is absent and its territory is supplied by enlarged branches from either the femoral nerve or the Ilioinguinal nerve.

4.2. Nerve supply of the muscles in the hip and pelvis region.

There are five regions to be considered;

- The *medial region is* formed by all the adductor muscles supplied by the obturator nerve, except for pectineus which is supplied by the femoral nerve.
- The *anterior* quadriceps femoris, and sartorius muscles supplied by the femoral nerve.
- The *lateral* region of the hip thigh through which most surgical incisions are made has the vastus lateralis (of quadriceps femoris and femoral nerve supply) and the tensor fascia lata muscle supplied by the superior gluteal nerve.
- The *posterior* region has the hamstrings supplied by the sciatic nerve. Generally, the hamstring muscles are minimally interfered with and cause little pain.
- The *buttock* muscles, lying more superficial and posterior, contribute to pain posterior to the hip joint after hip and pelvic surgery. They get strongly retracted and sometimes divided. They are supplied by the superior and inferior gluteal nerves. Superior gluteal nerve (L4, L5, S1) supplies the minimus and medius gluteus, and the tensor fascia lata muscles. The inferior gluteal nerve (L5, S1, S2) supplies the maximus gluteus muscle.

NOTE: Different surgical approaches injure different muscles, e.g. compare the anterior and posterior approach hip arthroplasties. See later.

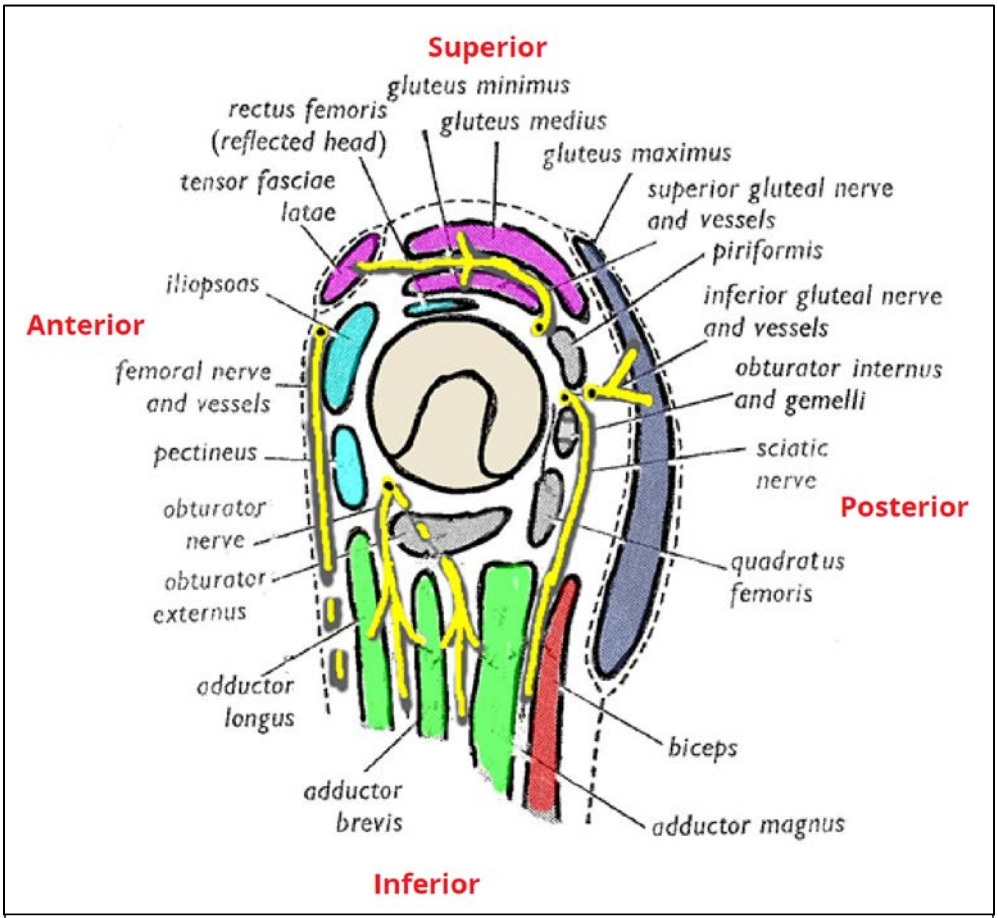


Figure #3. This is anterior-to-posterior coronal image slice through the head of the femur, looking towards medial. It displays all the muscle about the hip joint in their relative positions. Some muscles lie superficial and some lie deep, and in contact with the hip-joint capsule.

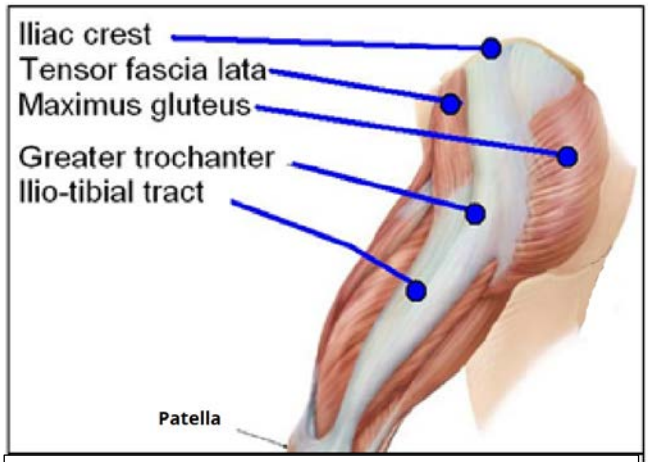


Figure #4. Tensor fascia lata and the ilio-tibial on the hip and thigh, viewed from lateral.

See figure number 4. The Ilio-tibial band is a substantial thickening of the fascia lata on the lateral aspect of the upper leg and hip. It is the longitudinal cleavage plane for surgical access to the hip and pelvis as it is the boundary between the pre-axial and post-axial parts of the leg with little risk of injuring major blood vessels and major nerves. The ilio-tibial band passes from the iliac crest to the lateral tibial condyle. The iliotibial band gives attachment superiorly to tensor fascia lata muscle, and on its posterior edge is attached to the muscle maximus gluteus.

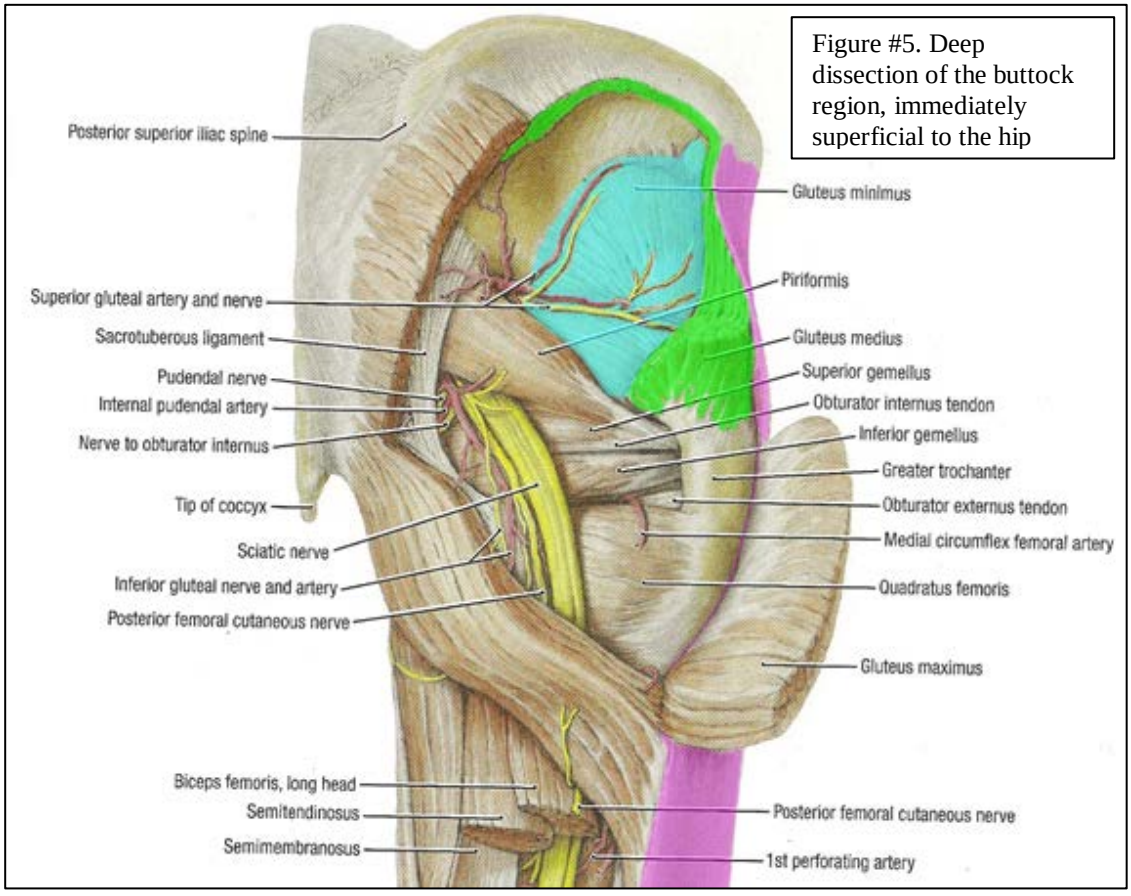


Figure #5. Deep dissection of the buttock region, immediately superficial to the hip

See figure number 5. It is a view of the partially dissected buttocks, viewed from posterior. See how maximus gluteus has been reflected, and gluteus medius has been dissected, to reveal the muscles that are integral with the posterior hip joint capsule. Those muscles are piriformis, superior gamellus, obturator internus, and inferior gamellus. With a posterior approach hip arthroplasty those muscles are divided and then sutured to restore them during surgical closure for completion of the arthroplasty. This causes severe posterior pain after the surgery.

4.3. Nerve supply of the pelvic and hip bones.

Surprisingly the nerve supplies have not been well studied and validated in science. However, there is no evidence suggesting the proposed osteotomes are wrong. The osteotomes illustrated here, are derived from extrapolating knowledge of species evolution and of human development.

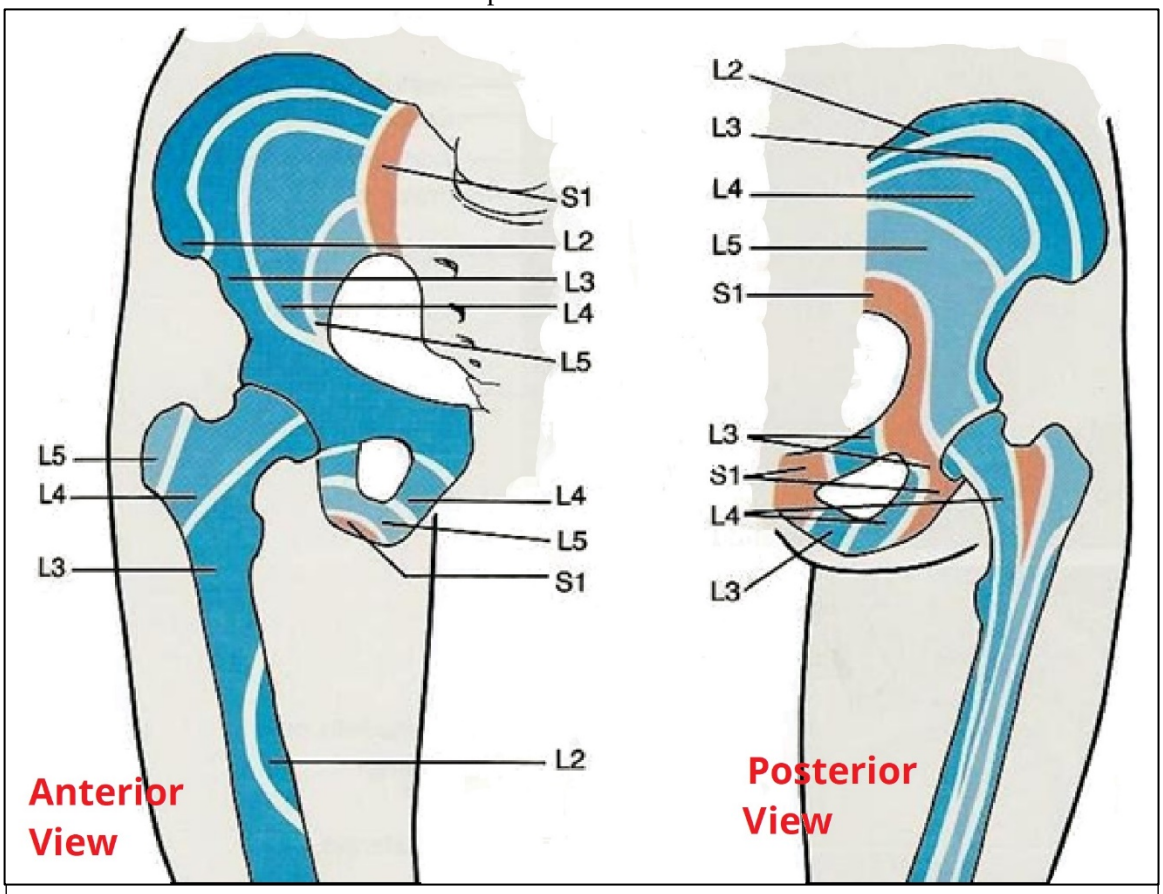


Figure #6. The osteotomes of the hip region.

See figure number 6. The iliac crest is supplied by dermatome L2 most superiorly and then caudad towards the hip joint through L3, L4, L5 and S1. The acetabulum is supplied by L4, L5 and S1.

The Femur greater trochanter is supplied by L5 and L4. The lesser trochanter is supplied by L3. The femur head and neck are supplied by L3 and L4. Proximal femur shaft is supplied by L2, L3 and L5. The principle nerve supplying the lesser trochanter region is the obturator nerve.

Those nerves travel with bone nutrient blood vessels. The nerve fibers also travel with the same nerve supplying the muscles attaching to those bone parts. Bones that are part of the joint will be supplied with sensation from the nerve of muscles acting close across those joints.

4.4. **Tissues and surgical pain.**

The skin incisions are initially painful enough to require opiates, but the pain is of short duration. Intensity diminishes rapidly in the first 24 hours. Nerve blocks for skin incisions may be single shot blocks if needed. Pain is readily controlled with oral non-sedating analgesic medication after 18 to 24 hours. Opiates are not needed for more than one day.

The muscle pain is initially severe and requires opiates. This source of pain is very dependent on the extent of the surgery and the approach used. It varies greatly with different hip surgical approaches. The nature of the surgery needs thus, to be known beforehand to plan the best regional anesthesia techniques. Anterior approach hip arthroplasty patients experience much less severe pain than patients having posterior approach hip arthroplasty surgery. Muscle pain resolves slower than skin pain and responds reasonably to opiates, sedating oral analgesics like NSAIDS and acetaminophen. Rest results in minimal pain, while movement can induce severe pain in the first 24 to 48 hours. It must be strongly noted however, that early movement despite inducing pain at the time, accelerates the rate of recovery. Accordingly, the patient should move as much as possible from the very start, within their threshold to tolerate the pain. This patient movement is a major factor in shortening the duration of pain (healing of the pain), as well as encouraging healing of tissues. Conversely keeping as still as possible and protecting the operated tissues from being touched or moved encourages pain duration to be extended. Keeping as still as possible after surgery also increases the risk of developing Complex Regional Pain syndrome (CRPS-type 1) later. Muscle pain is best managed with single shot nerve block lasting more than 6 hours, and ideally up to 20 hours beyond the end of surgery. Opiates may be needed for more than a day after surgery.

Articular pain (synovial pain) is severest, deep, burning in nature and requires opiates for more than two days, and strongly requires sustained nerve blocks.

Bone pain responds best to nerve blocks, particular those sustained by infusion for longer than 24 hours. Bone pain is severe **is,** deep aching in nature, and requires opiates in the absence of nerve blocks. Bone pain lasts longest, but steadily diminishes over a number of days. This responds very well to nerve blocks particularly if they are sustained for over 24 hours by infusion.

With repeat arthroplasty surgery, often the pain is less than that experienced with first time arthroplasties. One theory is that the tissues are partly denervated from the first surgery. This is however not necessarily true for an individual who may have deep tissue **hyperalgesia.** That exception individual may have the worst pain of all after surgery. Such an individual is identifiable before surgery and will usually have a history of recent or past allodynia and will manifest more than usual pain in the pre-operative period. Such an individual needs this hyperalgesia to be considered in the setting up of the anesthesia pain plan.

5. THE SURGICAL APPROACHES FOR HIP ARTHROPLASTY.

It is important to understand the surgery, in order to understand the best regional anesthesia techniques for hip surgery.

There are four basic surgical approaches. They are anterior, antero-lateral, lateral and posterior. Each approach has merits and de-merits. For the anesthesiologist each one is slightly different with respect to the patient position on table, the post-surgical pain that the patient will experience, and the surgical complications.

The principle nerves involved for the various tissues cut and injured are;

- Femoral nerve.
- Obturator nerve.
- Sciatic nerve.
- Superior gluteal nerves.
- Inferior gluteal nerves.

The different hip arthroplasty incisions (surgical approaches) injure different tissues;

1. The **anterior approach** is between the sartorius and tensor fascia lata muscles.
    a. Detach rectus femoris, iliopsoas [partial] muscles
2. The **antero-lateral** approach (commonest) is between the tensor fascia lata and gluteus medius muscles.
    a. Detach the hip abductor muscles (either do a greater trochanteric osteotomy, or cut gluteus medius)
    b. The Femoral nerve can be injured by the medial retractor.
3. The **lateral approach** allows earlier mobilization but is technically more challenging, and it splits maximus gluteus in length, and also vastus lateralis in its length. Gluteus medius is also split deep.
    a. The superior gluteal nerve can be injured.
    b. Femoral nerve can be injured by the medial retractor.
4. The **posterior approach** lies in between gluteus medius and gluteus minimus muscles, after first splitting the maximus gluteus maximus muscle. This approach best preserves abductor mechanisms. It is favored for redo-hip-arthroplasties. It opens the posterior joint capsule and detaches the two Gamelli, piriformis, and the obturator internus muscles. It has more risk for posterior dislocation after surgery, especially if the hip adducts.
    a. The Sciatic nerve is at risk from the medial retractor, and incision.

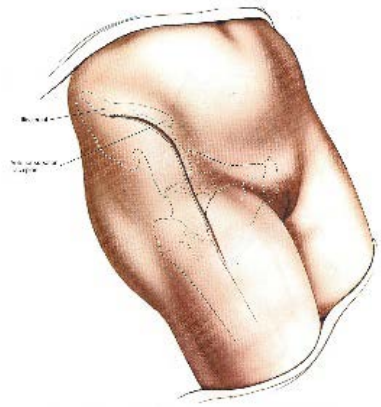
The choice of surgical approach (skin incision) depends on (i) patient considerations, (ii) joint prosthesis design, (iii) prior hip surgeries, and (iv) the surgeon personal preferences.

The surgical approach influences (i) whether the hip will be surgically dislocated towards anterior or posterior, (ii) whether the patient lies supine or lateral, (iii) the muscles to be cut or divided, (iv) the nerves at risk of injury, (v) the speed of the procedure, and (vi) the magnitude of post-surgical pain that the patient will experience.

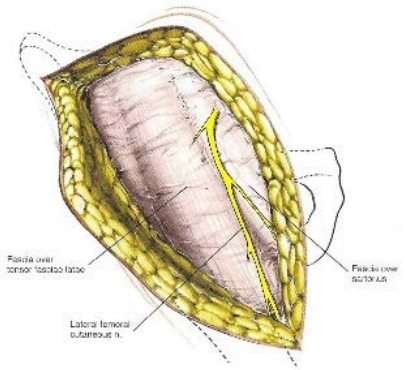
Generally, post-surgical pain is greatest when a muscle is cut across its fiber axis or cut off its origin or insertion. Splitting a muscle in its body parallel to its fibers is painful, but less than the pain seen with cutting across the fibres. Separating two muscles to find a dissection plane between two muscles is least painful. All bone cuts and osteotomies are very painful. The skin incision is only briefly painful, and for about 6 to 24 hours.

The anterior approach cuts the least tissue in its approach to the joint capsule and is least painful. It preserves the posterior capsule and the small adductors, thus having the lowest posterior dislocation risk after surgery. Finally, it preserves the femoral head blood supply and is ideal for acetabular resurfacing procedures[52.]

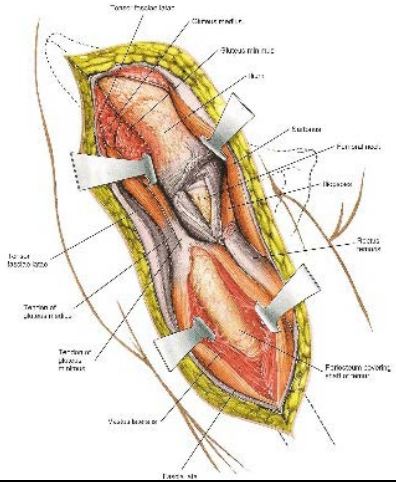
Anterior approach. Fig. 7a.



Anterior approach. Fig. 7b.

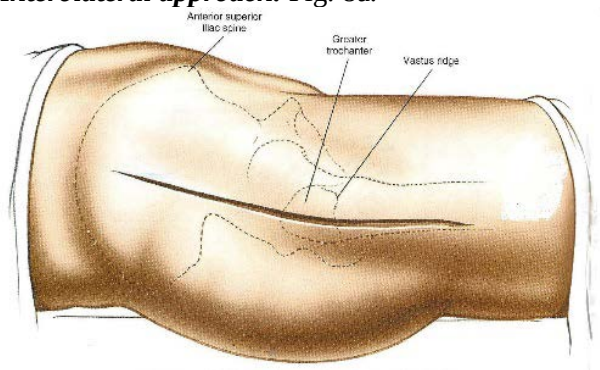


Anterior approach. Fig. 7c.

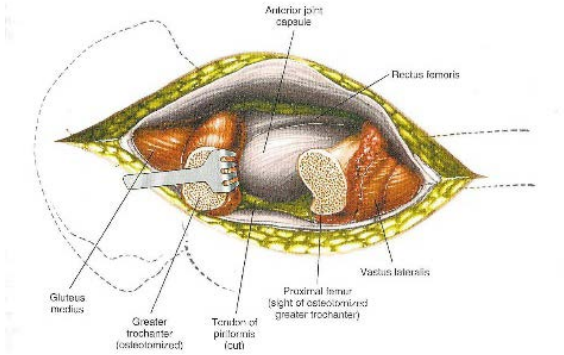


Anterior approach. Figure #7. Supine patient position. The superficial surgical plane cleaves between the sartorius and tensor fascia lata muscles. Divide the rectus femoris muscle. Resect the gluteus medius, gluteus minimus, and tensor fascia lata muscles from the ilium. Dislocate the joint to anterior. Retract gluteus medius and psoas muscles. Incise anterior joint capsule. Sometime split vastus lateralis.

Anterolateral approach. Fig. 8a.

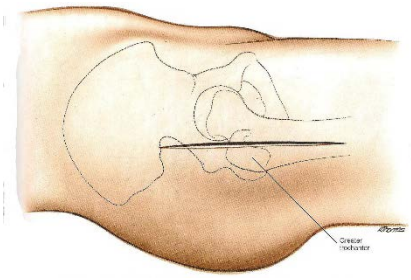


Anterolateral approach. Fig. 8b.

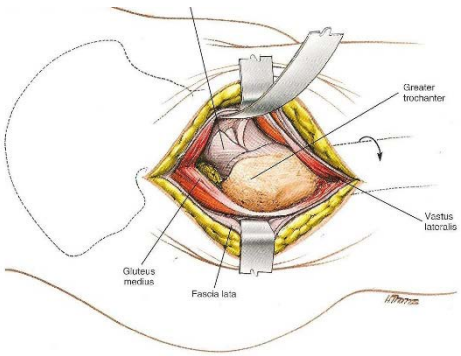


Antero-lateral approach. Figure #8**.** Supine position at the table edge. The superficial surgical plane cleaves between the gluteus medius and tensor fascia lata muscles. The gluteus medius and minimus distal attachment is osteotomized through the greater trochanter. The distal maximus gluteus may be split parallel to its muscle fibers. The femoral nerve can be injured during retraction.

Lateral approach. Fig. 9a.

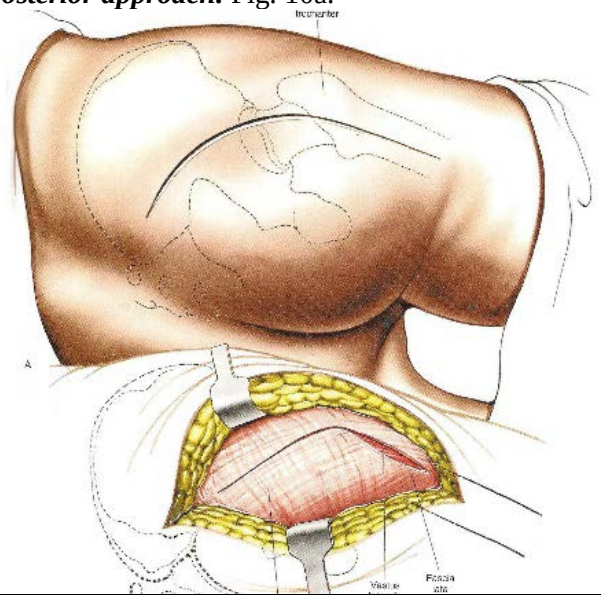


Lateral approach. Fig. 9b.

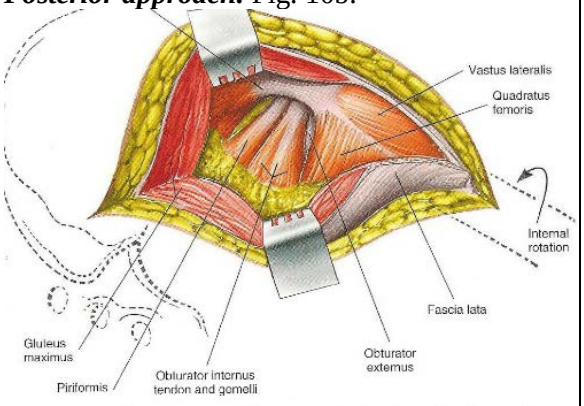


Lateral approach. Figure #9. Supine position at the table edge. Superficial muscle plane is through gluteus medius parallel to the muscle fibers. Nerve at risk; superior gluteal nerve (split M Medius too far proximal), femoral nerve (retractor injury). Detach the distal gluteus minimus from the trochanter.

Posterior approach. Fig. 10a.



Posterior approach. Fig. 10b.



Posterior approach. Figure #10The maximus gluteus muscle is split parallel to the skin incision and parallel to the muscle fibers. The external rotators quadratus lumborum, the Gemelli, obturator internus, and piriformis are divided. The posterior, superior and inferior joint capsule is cut. The sciatic nerve is at risk from medial retractor injury incidence ranges 0% to 7%. Probable modern risk is 0.17% with revision surgery[51].

6. SURGERY ASSOCIATED NERVE INJURIES

It is necessary to understand surgery associated nerve injuries to address surgeon concerns related to regional anesthesia. When a post-surgical nerve deficit occurs, it is initially hard to distinguish whether the etiology involves a surgical injury, a regional anesthesia cause or another unrelated cause. If nerve blocks were done, and injected as is optimal, prior to the surgery, then injury to the nerves can only become suspected after the usual expected time for recovery of the nerve block has been passed. For virtually all the potential nerve injuries associated with hip arthroplasty surgery none require immediate surgical exploration to save the nerve. Therefore, nerve blocks can be done prior to the surgery even if it delays the recognition os post-surgical surgery induced nerve injury. For the very rare and very specific one nerve injury that a surgeon may uniquely be concerned about, and would re-operate immediately upon its discovery, *then* the nerve block related to that nerve can be delayed until after the surgery, and after the specific nerve is seen to be functionally intact.

Mechanisms of nerve injury from surgery can be from severance (cutting), traction, retractor pressure, extremity positioning, limb lengthening, and cement induced thermal or pressure injury. The overall incidence of nerve injury after primary THR is 0.7% to 3.5%. The incidence doubles with revision procedures, and arthroplasties for developmental problems. The commonest injury by far, is the sciatic nerve in part or totally. The second most common surgical nerve injured is the femoral nerve. Anterior approaches have high propensity to injure the lateral cutaneous nerve of the thigh. The others are injured extremely rarely.

Subgluteal hematoma is a cause of sciatic nerve function loss and is recognized by pain in the buttock, swelling of the thigh and the buttock in addition to the loss of sciatic nerve function. Early decompression seems beneficial, if a compressing hematoma is

clinically suspected. Early postoperative hip dislocation can injure the sciatic nerve by stretch, and abduction pillows to prevent dislocation in turn have injured the common peroneal nerve at the fibula neck from tight straps across the nerve. In general, exploration of the sciatic nerve is recommended at six weeks after surgery, if there is no recovery at all by 6 weeks.

Femoral nerve injury may occur in up to 2.3 % of hip arthroplasty patients, is harder to diagnose than a sciatic injury, and is often overlooked but has a good prognosis regardless.

- LCNT neuropraxia occurred in 81% of patients after an anterior approach hip arthroplasty and 90% of those do not resolve by 12 months after surgery in one study[52]. In other studies, the incidence of LCNT neuropraxia is 4% with all recovering, but taking over a year to recover. Clearly the incidence is very technique dependent, hence such wide variation in incidence and outcome.
- The anterior approach is the most likely one to injure the femoral nerve.
- The posterior approach is the one most likely to injure the sciatic nerve.
- The postero-lateral approach is the one most likely to injure the superior gluteal nerve.

ADVANTAGES OF the anterior approach – it is the least painful approach. The approach incisions only separate two muscles, within a plane. It preserves hip abductors and posterior tissue envelope, resulting in the lowest incidence of postop hip dislocation to posterior. The anterior approach best preserves the femoral head blood supply which is advantageous for acetabular resurfacing procedures (without a femoral head prosthesis).

7. NERVE BLOCKS FOR HIP ARTHROPLASTY

What is regional anesthesia, for hip surgery?

Some surgeons or anesthesia providers presume that injection of a local anesthetic drug, in any dose or form into any tissue associated with the hip joint constitutes a "regional anesthetic". They thus, let the injection lay claim to all the benefits that other very different forms of local anesthetic injection have been shown to offer the patient. The benefits seldom transfer to techniques that are incomplete in providing tissue analgesia, that are of very short duration, and that fail in a substantial proportion of individuals in a study group. The goal has to be, to achieve 100% of benefits in 100% of individuals, or get very close to that ideal goal.

A correct point can thus be made that only **ideal** regional anesthesia techniques should be considered to raise the quality of care provided to hip-arthroplasty patients.

What is the ideal regional anesthetic for hip surgery?

This about the most important question in this entire chapter. An easier question to answer is what techniques are anesthesia-providers using on hip surgery patients? The German study of Donaur is the most accurate and authorative, and it is considered similar to the patterns of the USA[53]. Donaur reported that 63% of patients got general anesthesia. Mixed regional and general anesthesia was used on 14%, and regional anesthesia only was used on 23% of the patients. Of the regional anesthesia group alone 65% got a single shot spinal anesthetic, and 35% got catheter nerve blocks being spinal, or epidural blocks. Only 10% of the combined GA-RA group received peripheral nerve blocks. It seems the single shot peripheral nerve block group reported severe postoperative pain at some point due to breakthrough severe pain when the nerve block ended. There was not a well-managed transitioning between

analgesia phases, which may have diminished the reported actual analgesia benefits of the peripheral blocks.

When benefits and improved outcomes after surgery are attributed to *regional anesthesia*, it cannot be assumed that regional in anesthesia in any form and of any quality will equally win all the same benefits, and to the same extent. *Regional anesthesia* is a generic term encompassing an endless variety of techniques, drugs and doses.

For benefits to accrue to any specific regional anesthesia technique it will be one with all, or nearly all of these following features. They are thus ideal regional anesthesia features.

The **Ideal Features** of an OPTIMAL REGIONAL ANESTHETIC for hip arthroplasty are the following:

1. The regional anesthetic must be **functioning prior to surgery**, in order to have pre-emptive analgesia benefits.
    - If the regional anesthetic is initiated after surgery but before awakening of the patient, it is a high-level compromise, but better than doing it in the recovery room (PACU) after the patient is awake.
    - If the regional anesthetic is initiated after the patient is awake and is already in pain, it is a low-level compromise technique, and better than no nerve block.
2. The regional anesthetic must **provide total anesthesia, and total post-operative analgesia** to all tissues subjected to dissection, cutting, handling, or tourniquet.
    - A *minimum compromise regional anesthesia technique* must suppress post-operative PCA morphine consumption by 50% at the least, to be worth while doing. Any reduction of less than 50% in the 24h PCA morphine consumption will not reduce patient subjective pains score or improve satisfaction scores.
    - If the regional anesthesia technique can reduce 24h PCA morphine by 70% or more, then the addition of non-sedating analgesics (acetaminophen, NSAIDs) for the unblocked pain will be very effective. Pain scores will approach 1 to 2 on a 10-point scale and patient satisfactions scores will be very high. This would then be *optimum compromise regional anesthesia technique*.
3. The regional anesthetic analgesia-effects should **last for 24 hours or ideally for 48 hours after surgery.** Typically, this would be facilitated either repeated nerve blocks, or by infusions of local anesthetic via perineural or neuraxial catheters.
    - A *top optimum compromise technique* would have one major regional anesthesia technique component's effects be sustained by perineural or neuraxial infusion of local anesthetic, and the other component of the regional anesthesia technique be single shot injection's effects be able to last 8 to 18 hours after the surgery.
    - A *middle optimum compromise technique* would have one regional anesthesia technique cover the major part of the tissues injured by surgery and be sustained for 24 hours to 24 hours after surgery. The unblocked tissue portion would need treatment with opiates acetaminophen and NSAIDs.

- A *low optimum compromise technique* would have one single shot technique cover the major part of the tissues injured by surgery and have the analgesia last 12 to 18 hours after surgery. The unblocked tissue portion would need treatment with opiates, acetaminophen and NSAIDs.
- Anything less than the above techniques would be an *insufficient value technique* and unlikely to produce any regional anesthesia benefits, other than a slight reduction in primary anesthetic drug doses facilitating a faster wakeup by about 10 minutes.

A. NEURAXIAL nerve blocks.
   - Spinal anesthesia has the advantage of being technically easy, being used ubiquitously for a wide variety of surgeries, and the skill to perform it is very widely distributed amongst anesthesia providers. Its principle limitation is the surgery must be completed within 3-hours, and there is no post-surgical analgesia from the local anesthetics.
     - Harsten and Kehlet compared spinal anesthesia to TIVA- general anesthesia in hip arthroplasty patients in 2015[54]. There were no spinal opiates used. The early recovery features were best, although with small actual differences, with general anesthesia, although the general anesthesia patients had more pain during the first two hours after surgery. The opiate usage by both groups were however identical over the full 1st 24 hours after surgery. The context of the study was to optimize fast-track patient handling, ending in earliest discharge. They did not review longer term outcomes. The results can also be interpreted that the was no clinically relevant difference between the groups. In other words, both spinal and general anesthesia are acceptable in the very short term for hip arthroplasty patients.
   - Epidural anesthesia has advantage over spinal anesthesia in that catheters are easily placed and are very effective in sustaining analgesia after surgery.
   - The limitation of neuraxial blocks concerns; their risk for causing paraplegia from a compressing spinal-hematomas, and their interactions with anti-coagulant therapy.

Neuraxial blocks are popular in random centers, but neuraxial blocks are not a world standard of practice. In 2013, for hip and knee arthroplasty combined, 64.45 of USA patient received only general anesthesia, 22.8% only a neuraxial anesthetic, and 12.8% received a peripheral nerve block alone or added to another primary anesthetic[55].

B. PSOAS COMPARTMENT BLOCK. This has been the most **popular block** for hip arthroplasty for decades. Typically, it is combined with general anesthetic for the surgery. It replaced the neuraxial block only technique, and general anesthesia only techniques. Chelly from Pittsburg reported outstanding analgesia results with large reductions in opiate related side-effects[56]. The psoas block provides (1) a lateral femoral cutaneous nerve block, (2) a femoral nerve block, and (3) an obturator nerve block all of which are needed for hip arthroplasty. It is the only main peripheral nerve block worth doing for hip arthroplasty due to the fact is can be performed proximal and far from the surgical field. For awake hip surgery it is however incomplete for analgesia, without the supplementary blocks of (i) the

parasacral sciatic nerve block, and the (ii) hip-focused subcostal nerve block. The psoas block is foremost an analgesia block for post-surgical pain. It can be used for awake surgery if combined with a parasacral sciatic nerve block and a subcostal nerve block over the iliac crest. It then needs a 45-minute waiting period to develop ("soaking time"), as it is characteristically a slow onset block.

C. PARASACRAL SCIATIC NERVE BLOCK; Advantages; The following nerves accompany the sciatic nerve at this site and are also nerve blocked; (1) superior gluteal nerve [supplying the minor and medialis gluteus muscles], (2) the inferior gluteal nerve [supplying maximus gluteal muscle]. In addition, the sciatic nerve supplies the branches to piriformis, the gemelli, and obturator internus all adherent to the hip joint posterior capsule. Substantial pain can come from the cutting of, all these muscles with various hip arthroplasty approaches, in particular the posterior approach. More distal sciatic nerve blocks, such as the GT-IT line sciatic nerve block, do not block the two gluteal nerves and is thus unsuitable for hip surgery. The parasacral sciatic nerve block is only used for hip surgery, when in combination with the psoas compartment block.

D. HIP-FOCUSSED SUBCOSTAL NERVE BLOCK;

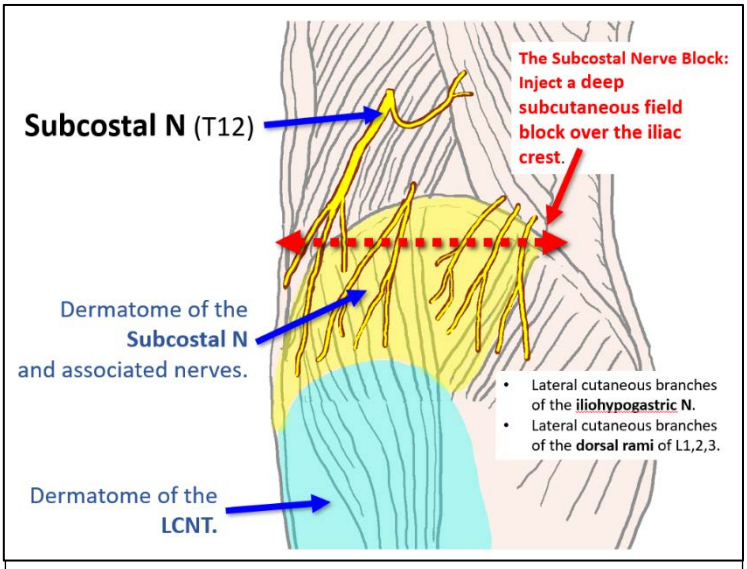


Figure #11. The hip focused subcostal nerve block.

This simple block can be performed a subcutaneous infiltration immediately superficial to the iliac Crest starting from the Anterior Superior Iliac Spine (ASIS) and then to posterior for 80 to 100 millimeters. See figure number 10. This covers the most cephalad part of the hip arthroplasty incision in the zone cephalad to the highest extent of the lateral cutaneous nerve of the thigh dermatome. It is done combined with the parasacral sciatic nerve and the psoas compartment blocks. The triple block combination provides 100% analgesia. Pain score will be zero, with the patient being on zero opiates.

E. FEMORAL NERVE BLOCK. Firstly, it is injected very close to the incision line for an anterior surgical approach and is thus suboptimal for continuous infusion catheter insertion. As a nerve on its own alone for hip arthroplasty, it does not alter patient pain scores, does not improve satisfaction scores, and only reduces morphine consumption 40%. It is not worth doing alone.

F. FASCIA ILIAC BLOCK; This block in theory, is supposed to reliably block the femoral nerve AND the lateral cutaneous nerve of the thigh (LCNT). In truth it gives a late onset and early offset femoral nerve block with frequent failures. It also fails to block the lateral cutaneous nerve of the thigh in about 25% of cases due to anatomic variants in that nerves path. Various inexpert physicians are attracted to this block, because it seems safer being far removed from the femoral artery. In truth, it is a poor block not worthy of any real regional anesthesia expert doing it and there are better blocks to do for these two nerves. It is the psoas compartment block, which includes an obturator nerve block. The supra-inguinal fascia-iliaca

block is however reasonable in thin and non-obese patients, if done under ultrasound visual guidance

Comparative studies of regional anesthesia techniques for hip arthroplasty have been done. Dauri studied three different techniques[57]. He did not describe the approaches used for the hip arthroplasties. Patients with managed intraoperatively with propofol and sufentanil infusions and with spontaneous breathing. Using a psoas compartment block alone produced less analgesia than using an epidural or a psoas compartment block combined with a parasacral sciatic block. Beyond 12 hours after surgery, all three groups were clinically similar for pain control. This clearly showed the value of adding a single shot parasacral sciatic nerve block to a psoas compartment block. The epidural block had an 8% technical failure rate, while no peripheral nerve blocks had any technical failures. The epidural group need urine catheters immediately postoperatively while the peripheral nerve block groups could give up their urine catheters postoperatively. The three groups were similar for blood loss and intraoperative hemodynamics, except the epidural group alone which had lower postoperative blood pressures.

On balance of all consideration, the author recommends the psoas compartment block with a parasacral sciatic nerve block as the optimum analgesia technique for hip arthroplasty. General intraoperative management must either be light general anesthesia with airway control, or a deep sedation-analgesia technique with an uncontrolled airway. The better technique will include the airway control element.

7.1. NERVE BLOCK TECHNIQUES

7.1.1 PSOAS COMPARTMENT BLOCK for HIP-PELVIC SURGERY

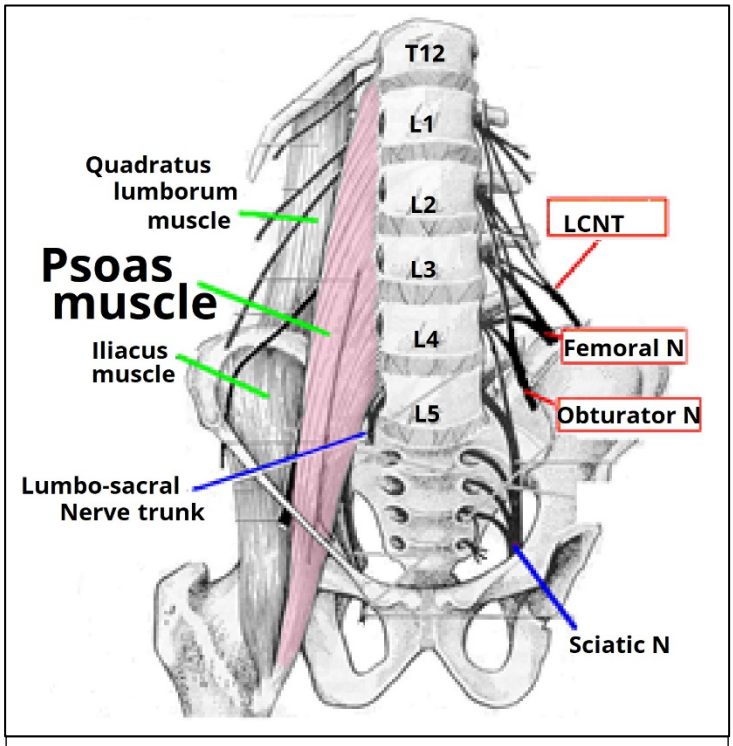


Figure #11. The psoas muscle.

The lumbar plexus is formed within the psoas muscle. For "low" psoas compartment blocks that are performed adjacent to the 3rd to 5th lumbar vertebrae" all the lumbar plexus branches relevant to the hip and pelvis will be blocked. The psoas muscle's lowest attachment is the upper edge of the 5th lumbar vertebral body.

The 4th lumbar spinal nerve gives off a branch that exits the psoas muscle immediately towards medial, where it joins the 5th lumbar root to form the lumbar-sacral trunk. This lumbar sacral trunk is the largest contributor to the sciatic nerve (L4 to S3) and it represents itself dominantly in the common peroneal nerve portion of the sciatic nerve. A typical psoas compartment block thus only blocks that one L4 portion of the

sacral plexus and sciatic nerve. A typical psoas block has no clinically recognizable sciatic or sacral nerve block component. Drug injected in the psoas muscle generally does not escape the muscle compartment and drug injected outside the muscle does not readily enter the psoas muscle compartment.

Following an attempted psoas compartment block, there is occasionally a full sciatic nerve block combined with a fully failed psoas block. This is when the needle is placed at the L5 level and the needle-tip ends medial to the psoas muscle where it is free and unattached to the 5th vertebral body. The drug is perfectly placed for sciatic nerve block as it will spread paravertebral down a few segments.

Occasionally in about 5% or less of psoas blocks, there is a prefixed lumbar and sacral plexus. This means nerve roots are shifted up a level on the vertebral axis relatively, and the equivalent of the lumbar-sacral trunk with is usually made up the ventral-roots, half of L4 and all L5, becomes half of L3 and all of L4. Clinically there is still a satisfactory psoas compartment block, but with an additional partial sciatic nerve block of the common peroneal nerve portion of the sciatic nerve.

Abnormalities of the lumbar and sacral plexuses related to shifting up or down a level are associated with lumbarization for the S1 vertebrae and sacralization of the L5 vertebra. This means standard clinical counting of vertebral levels could count one level too high or one level too low. As going one level too low permits the rare failed psoas – full sciatic nerve block to occur (as described above) it is best to perform the psoas block opposite L3. If the level is misidentified and a block is done at L2 or L4 unknowingly a satisfactory psoas block will always still result, but never a full sciatic nerve and failed psoas block as can occur with an unrecognized attempted L5 level insertion.

A psoas block is popular for hip arthroplasty post-surgical analgesia. It is however often insufficient and much opiates and multimodal analgesia is still needed. Examination of the patient then often reveals pain immediately posterior to the incision into the buttock region. This is from surgery involving the gluteus muscle and pain results from incision, bruising and retraction. The addition of a parasacral sciatic nerve block to the patient's analgesia usually resolves their complaints dramatically. A supplementary parasacral sciatic nerve block is recommended, and then a virtual 100% analgesia with good consistency of results.

This author does this routinely.

Psoas compartment blocks need large volumes in order to spread the wide distances. Forty milliliters of drug is the ideal volume for all adults. Occasionally a contralateral short segmental sensory-only loss is discerned at the lumbar level dermatome of injection. That is a harmless side effect. Injecting larger volumes does not enhance the ipsilateral block, but it does tend to increase the contralateral block features. Reducing the volume, say to 30 milliliters can result in a less than 100% block in about 1/3 of the patients. Only use 30 milliliters bolus injection for a psoas compartment block in a patient of small stature, and where there is concern for the total of multiple nerve blocks exceeding a safe limit for ropivacaine. Avoid do this block with bupivacaine as it limits the ability to do additional nerve blocks because of the risk of local anesthetic toxicity.

Psoas compartment block are large volume blocks both in the bolus needed to initiate the block, and in the hourly volume to sustain the block. Ideal infusions drugs and rates is 0.2% ropivacaine at a rate of 12 to 15 ml per hours. It is also good to do second bolus injection at 3 to 4 hours after the first bolus. Typically, the patient will then be in the post-anesthesia care unit (PACU). That second bolus ensures that the infusion is very effective for the next 36 to 48 hours.

7.1.2. THE PARASACRAL SCIATIC NERVE BLOCK.

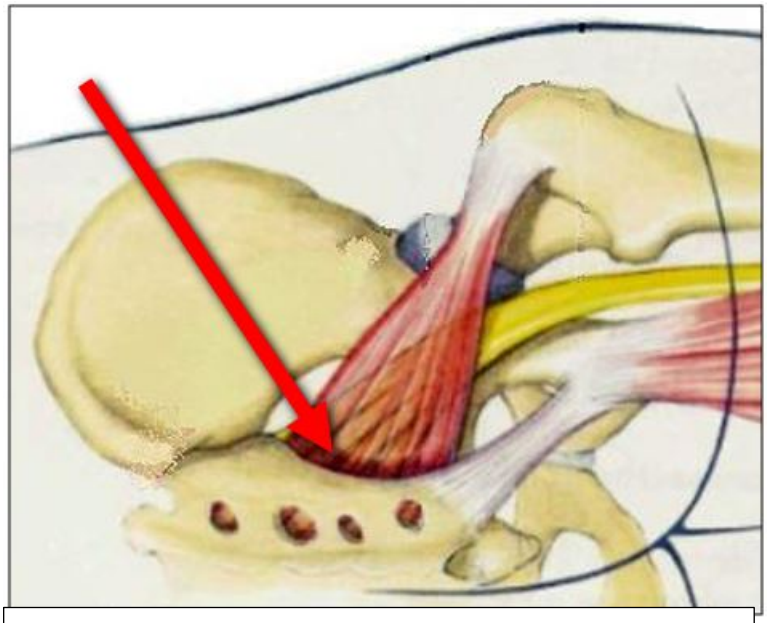


Figure # 11. The sciatic nerve emerging into the buttock regional at the lateral edge of the sacrum. The red arrow indicates the best injection point

See figures numbers 11 and 12. The parasacral nerve block is performed in the lateral position with the upper hip well flexed to the posterior superior iliac spine (PSIS) and the ischial tuberosity. Needle insertion point is on the line between the bony point 6cm caudad to PSIS and is directed direct to anterior.

A twitch of the tensor fascia lata muscle, on the most lateral part of the upper thigh, indicates the needle tip is immediately cephalad and lateral to the sciatic nerve. First advancing the needle 2 cm deeper. If no sciatic nerve is found, then try redirecting the needle tip 3mm more medial to seek the sciatic nerve.

A twitch of the maximus gluteus muscle indicates the needle is likely immediately caudad, and medial to the sciatic nerve. First try advancing 2 cm deeper, and if no sciatic nerve is found, then withdraw the needle 2 cm and redirect the needle 3 mm more lo lateral. A hamstring twitch is the commonest "positive" twitch found representing the sciatic nerve. Adjust needle position until a minimum stimulating current of under 0.6 mAmp is obtained and inject local anesthetic.

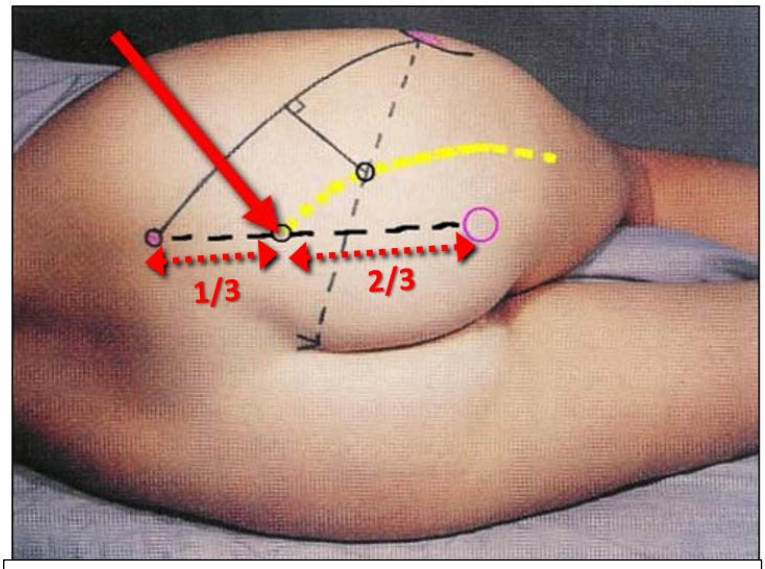


Figure #12. The surface position to insert the needle for the parasacral sciatic nerve injection. NOTE: Figure #11 demonstrates the unseen deep anatomy.

Alternate "positive end points" for the needle tip final position are indicated by any muscle twitches below the knee. Lower leg twitches do not indicate needle tip positions superior to ham string twitches, and there is no need to look for them if a ham string twitch is obtained.

WHAT DRUG?
Answer = ideal is ropivacaine 0.375% or 0.75%. It is NOT desirable to have a sciatic nerve block last longer than the next morning. A reduced volume and concentration make one confident the block is resolved by the next morning and where after, residual foot weakness may indicate a surgical sciatic nerve injury has occurred.
WHAT VOLUME to INJECT? A = twenty ml is perfect for the parasacral sciatic nerve block. Lesser volumes often fail to achieve analgesia of the 3 target nerves, being the sciatic nerve, the superior gluteal nerve, and the inferior gluteal nerve. Greater volumes can cause retention of urine due to spread to autonomic nerves of the pelvic viscera. Urine retention due to bladder paralysis from a parasacral sciatic nerve block is a rare side-effect, and only seen of very large volumes are injected. This author has been seen this only with injections of 40 ml, but never with doses of 20ml local anesthetic.
WHAT SIDE EFFECTS; The special one to mention to the patient is there is occasionally some spill-over onto the pudendal nerve. Woman mostly do not notice this perineal numbness, but some men, if not forewarned, find penile numbness exceedingly disturbing.

7.1.3. **THE HIP-FOCUSSED SUBCOSTAL NERVE BLOCK.**

The most cephalad portion of hip arthroplasty incisions reach up to the iliac crest and may run along it for a short distance. This most cephalad incision part is beyond the dermatome of the lateral cutaneous nerve of the thigh (LCNT). See figure number 7a. This very easy supplementary skin block will cover that area. A simple subcutaneous local anesthetic infiltration over the iliac crest in the anterior and mid axilla lines will block the branches of L1-3, the subcostal nerve and the iliohypogastric nerves. The genetic variance between these nerves and their skin distributions does not matter with this technique. All those nerves will always be blocked by this injection. See figure number 14.

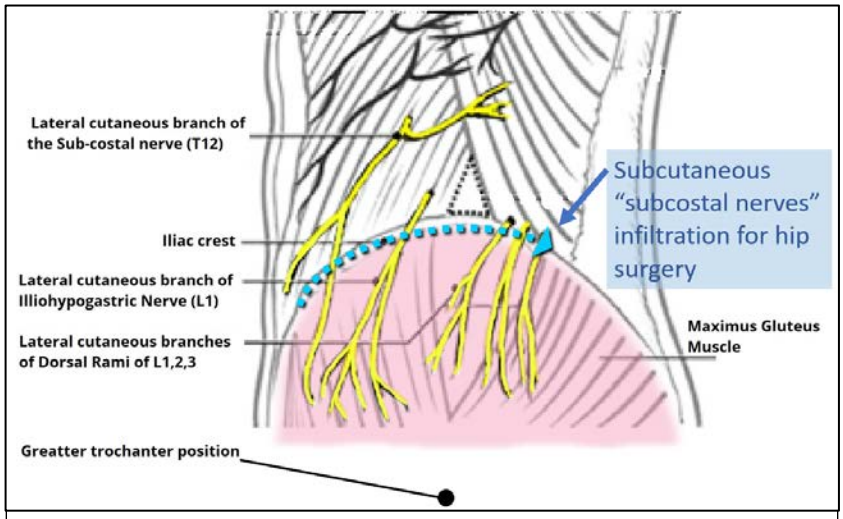


Figure #14. Where to inject to anesthetize the skin in between the iliac crest, and the cephalad end of the LCNT dermatome.

Insert a 90mm needle from anterior towards posterior. Start over the anterior Superior Iliac spine (ASIS) and inject for a 90 to 100mm distance immediately superficial to the iliac crest. Us a long acting local anesthetic, with the maximum volume and concentration constraints of the total drug limits for the multiple nerve blocks that must be done.

Ideal volumes are 10 or 15 milliliters. The ideal drug is levobupivacaine for its long duration and low toxicity, but ropivacaine is nearly as satisfactory. Concentrations of 0.25% to 3.75% mostly give satisfactory results.

When the patient is obese it is important to remember that subcutaneous nerves lies closer to the deep fascia of the body than to the dermis of that area. So, inject “deep” subcutaneous, but not under any fascia. Experience is invaluable.

7.14. Fascia iliaca block.

This block conceptually provides a femoral nerve block and a lateral cutaneous nerve of the thigh (LCNT) block. It's limitations for hip surgery are; (i) the conventional infra-inguinal site of injection is very close to the planned surgical injection and increases the risk of surgical sepsis, (ii) the drug has to flow a distance subfascial to reach the femoral nerve, and compared to direct femoral nerve injection the femoral nerve component sets up slowly, weakly, inconstantly and only briefly, (iii) due to much anatomical variation in the lateral femoral cutaneous nerve of the thigh (LCNT)it fails to be blocked in 20% of cases. So, this classic approach is not recommended.

There has been interest in performing this block cephalad to the inguinal ligament. That would be further from the surgical fields, and conceptually might increase the success rates of blocking the LCNT. That approach is impossible in markedly obese patients. Gasanova studied it in 2019, comparing it to hip arthroplasty periarticular local anesthetic infiltration[58]. He found that the block had no analgesia advantage over a surgeon-administered peri-articular infiltration block, and the block only additionally caused a mild observable hip muscle weakness last for the first 6 hours.

In 2018 Ueshima reported successful use of supra-inguinal fascia iliaca block for awake hip arthroplasty surgery on an aged ill patient[59]. Only dexmedetomidine was additionally administered to the patient during surgery. The authors regarded themselves as having injected superficial to the fascia covering the iliacus muscle, but the ultrasound images suggest the drug fluid is deep to the fascia investing the iliacus muscle, as would be the site the nerve was expected to lie. Although this single block worked for this patient undergoing a hip arthroplasty for femur neck fracture, it is unlikely this single block would be satisfactory for awake surgery for a Total Hip arthroplasty. The patient had a femur neck fracture and received only femoral head and neck replacement. It was bipolar prosthesis meaning the head was fitted into the natural acetabulum without any traumatic surgery to the acetabulum or posterior capsule. A bipolar femur head prosthesis has swivel mechanism built into it between the steel head and the steel neck. That neck-head swivel then effectively becomes the "functioning hip-joint". Also, the femoral cut did not involve the femur near the lesser trochanter, which has a nerve supply from the obturator nerve. That is why the block was adequate. For full total hip arthroplasty awake surgery would have been impossible without an additional obturator nerve block and parasacral sciatic nerve block. Lastly the block worked well because of the very large block volume injected, of 20 milliliters of local anesthetic in a tiny lady of 4ft 8in (1.48M) weighing 45 kg. The large volume assured wide spreading of the drug. O

Figure #16
Bipolar femur head prosthesis.

7.1.5 Surgeon administered regional anesthesia blocks, intra-operative.

These are techniques of local anesthetic administration injected by the surgeon within the open operating field, generally towards the conclusion of the surgery. In general, they were worthy of evaluation, but largely have fallen very short of what better anatomically-targeted peripheral nerve block by the anesthesia provider can perform. An added note is that they contribute nothing towards pre-emptive analgesia, by being injected at the conclusion of surgery.

1. **Intra-articular flooding with local anesthetic and continuous infusion**[60]. The immaculate study was prospective, randomized and blinded. There was only a slight analgesia benefit to the bupivacaine group, over the saline control group that lasted only 34 minutes longer after the end of surgery. The block is clearly useless.
2. **Local Infiltration analgesia (LIA).** This is also called peri-articular Infiltration analgesia (PAI). The review on this by Kehlet in 2011 concluded that infiltration techniques for hips showed no efficacy (compared to placebo) and that infusion techniques failed to induce any measurable analgesia benefit[61]. The study by Dobie showed no analgesia benefit from LIA injected after hip arthroplasty, in terms of early mobility or analgesia[62]. That study did suggest efficacy of the technique versus no therapy (placebo). The study needs validation by other researchers showing similar results, and the technique finally also needs comparison to other "best analgesia" techniques like multiple peripheral nerve blocks. It is recommended not to use this block.
3. **Intra-op extreme caudad psoas compartment block.**
   This technique has been used by some surgeons. It was first described by Green in 2014, where he injected within the most caudad portion of the psoas muscle that was visible in the surgical field, and he showed a positive efficacy compared to a placebo[63], [64]. Fahs compared this block to hip periarticular local anesthetic infiltration[65]. This sub-inguinal-ligament injected psoas block was significantly inferior for analgesia up to three hours after surgery, and thereafter the two techniques had no differences. As hip periarticular infiltration has been abandoned for lack of good enough benefits, so should this extreme distal psoas block injected intraoperatively be abandoned.

7.2. Recommended nerve blocks for different hip arthroplasty surgical approaches.

Anterior incision hip arthroplasty. Best nerve block option = block three nerves	
1. **Psoas compartment** block, Inject 30 to 40 ml 0.75% ropivacaine. Add an infusion.	Psoas block alone will reduce opiate consumption about **75%.**
2. **Parasacral sciatic nerve** block: 15 to 20 ml 0.5% to 0.75% ropivacaine. No infusion`	The addition of this block will reduce opiate consumption about **20%** after surgery
3. **Subcostal nerve** hip focused block 5 to 10 ml 0.5% to 0.75% ropivacaine.	This easy and safe block will reduce post-operative opiate consumption by about **5%**. The block biggest value is however, for during surgery.
Anterior incision hip arthroplasty – 2nd Best nerve block option = psoas only.	
1. **Psoas compartment** block, Inject 30 to 40 ml 0.75% ropivacaine. Add an infusion.	Use full dose opiates initially at the end of surgery, and full multimodal analgesia for the unblocked surgical portions. There is still merit in doing this block, even without an accompanying sciatic and subcostal block
Lateral and postero-lateral incision hip arthroplasty. Best nerve block option = 3 blocks.	
1. **Psoas compartment** block, Inject 30 to 40 ml 0.75% ropivacaine. Add an infusion.	Psoas block alone here will only reduce opiate consumption about 65%. Use full dose opiates initially at the end of surgery, and full multimodal analgesia for the unblocked surgical portions. There is still merit in doing this block, even without an accompanying sciatic and subcostal block
2. **Parasacral sciatic** nerve block: 15 to 20 ml 0.5% to 0.75% ropivacaine. No infusion	The addition of this block will reduce opiate consumption about 30% after surgery. This additional block is highly recommended.
3. **Subcostal nerve** block 5 to 10 ml 0.5% to 0.75% ropivacaine.	This easy and safe block will reduce post-operative opiate consumption by about 5%. The block's biggest value is however, for during surgery.
Posterior incision hip arthroplasty. Best blocks option	
1. **Psoas compartment** block, Inject 30 to 40 ml 0.75% ropivacaine. Add an infusion.	The psoas block alone will reduce 24h PCA morphine by 45% but will not produce lower pain scores or patient satisfaction improvements. This block is thus arguably not worth doing, without an accompanying parasacral sciatic nerve block. The posterior pain is severe for 24 hours
2. **Parasacral sciatic** nerve block: 15 to 20 ml 0.5% to 0.75% ropivacaine. No infusion.	This block alone will reduce 24h PCA morphine consumption by 50%. The psoas block on its own is worthless without this parasacral sciatic nerve block added in. The parasacral sciatic block is barely worth doing, on its own.
3. **Hip focused Subcostal** nerve block. Inject 5 to 10 ml 0.5% to 0.75% ropivacaine.	This easy and safe block will reduce post-operative opiate consumption by about 5%. The block's biggest value is however, for during surgery.

8. PRACTICAL REGIONAL ANESTHESIA CHALLENGES WITH MAJOR JOINT ARTHROPLASTY.

There are two major logistical problems to implementing peripheral nerve blocks for arthroplasty patients.

(1) Lack of regional anesthesia **skills** amongst anesthesia providers. Only a minority of anesthesia providers can perform the range of nerve blocks required for hip arthroplasty. Even fewer can insert perineural catheters. It is estimated less than 10% of USA anesthesia practitioners could be considered experts in peripheral regional anesthesia. Only 0.7% of USA anesthesia providers attend the national regional anesthesia annual conference.

(2) Orthopedic surgeons are generally intolerant of delays in operating, due the performance of regional anesthesia procedures. It is noteworthy, there is evidence that if a single single-shot nerve block was performed in the operating room, the extra time that was needed for the procedure in the beginning was less than the time gained at conclusion of the case from a faster patient recovery time. In other words, there was net reduction in operating time due to performing the nerve block, even in the operating room. The surgeon arguments about nerve blocks wasting operating room this are thus invalid, apart from being uncaring about the patient.

(3) Lack of anesthesia resources. The most efficient regional anesthesia services have **extra** physicians, nurses and procedural rooms. This allows the nerve blocks to be performed on a patient, while the patient is waiting for the preceding patient's surgery to be completed.

Post-surgical analgesia plans after hip arthroplasty surgery, can be divided into three groups based on what the specific anesthesia provider's regional anesthesia skills are;

A. Non-skills-based analgesia.
B. Minimal skills-based analgesia
C. Advanced skills-based analgesia.

A. *Non-skills-based analgesia* refers to analgesic drugs that are administered via oral, intravenous or related routes. All anesthesia providers can prescribe and administer these drugs. That would include opiates, NSAIDs, ketamine and acetaminophen.

B. *Minimal skills-based analgesia* is neuraxial anesthesia (spinal or epidural block). A majority although not all anesthesia providers can perform these procedures reliably and safely.

C. *Advanced skills-based analgesia* refers to peripheral regional anesthesia. It is not a national, nor an international standard to train all anesthesia practitioners as experts in regional anesthesia. Licensing requirements only demand a nominal exposure to an incomplete range of nerve block procedures during training. A minority of education centers could be described as centers of regional anesthesia excellence. Many anesthesia providers only get enough training in peripheral regional anesthesia to know the principles involved and to perform about two to four simple non-continuous nerve blocks with marginal competence.

THE REMEDIES to the above problems include the following steps;

(1) Increasing post-graduation education opportunities on regional anesthesia for all anesthesia providers
(2) Educating anesthesia providers more about regional anesthesia during basic training. Extending basic training by extra year dedicated to regional anesthesia training would be very good.
(3) Educating the public about their rights to best post-surgical pain control.

(4) Educating orthopedic surgeons on the benefits of regional anesthesia and the dangers and disadvantages of intrathecal water-soluble opiates.
(5) Institute regional anesthesia process management pathways in anesthesia groups or surgical institutions. Process management pathways include two concepts; The ANALGESIA PATHWAY and PARALLEL PROCESSING

A. ***THE ANALGESIA PATHWAY.***

This concept was popularized by Mayo Clinic who are leaders in regional anesthesia for major joint arthroplasty. James Hebl, from Mayo Clinic lectures widely on the Analgesia Pathway.

There are two arms to the analgesia pathway;

- THE DRUG PLAN; It concerns the integrated planned and phased analgesia therapy of the patient starting with preoperative drugs, through the surgery, the early postoperative period, transitioning therapy into the intermediate post-operative period, and the final transition to oral non-sedating analgesics.

  The drug plan could include a COX2-I, or NSAID and acetaminophen premedication, plus minus Gabapentin. Peripheral nerves blocks would be central to the anesthetic and postop analgesia plan. The primary anesthetic could be general or neuraxial as per patient preferences and patient needs. A small dose of ketamine is required and also the general avoidance of opiates until awakening. Upon awakening, long-acting rescue opiates can be used as needed without restriction for a modest period. Nerve blocks should be blocks that have in excess of 12 hours effect and preferably 24 hours to 48 hours of effect, as per surgeon's preference.
- THE NERVE BLOCK PLAN; It concerns the organized way patients are processed from arrival at the operating rooms, through getting nerve blocks pre-operatively parallel to the preceding patient still undergoing surgery, and finally through the maintaining of regional anesthesia infusions after surgery. Goals are to minimize time spent not operating between sequential patients.

B. PARALLEL PROCESSING

One method of saving time is parallel processing. That means starting anesthesia care of one patient, congruent in time to the anesthesia care of a preceding patient. Both patients will be operated on in the same operating room, one following the other. In other words, part of two patients' anesthesia care will run parallel to each other in time. In practice, this mainly means performing the nerve blocks prior to the patient entering the surgical operating room. It does require a duplication of staff and facilities (rooms). It has been shown that extra operating time can be obtained from use of parallel processing with joint arthroplasties[66]. The extra surgeries performed can off-set the costs of extra anesthesia staff and extra procedural space. Also remember the patient's health needs are a priority above that of hospital profits.

Success requires the orthopedic surgeons agree to the patient receiving regional anesthesia and support the anesthesia department/group in providing regional anesthesia. The Analgesia Pathway cannot be arbitrarily prescribed by either the surgeons or the anesthesiologists. It must be jointly agreed upon and have an enthusiastically supported plan in order to succeed.

There are extra costs involved from the extra personnel (nurses and anesthesiologists) and the extra rooms this requires. Increased turnover of cases does increase income. A very well thought out plan has to assure that no role player (hospital/surgeon/anesthesiologist) carries any unfair financial burden and that increased expense and increased income are wisely balanced. The system is less functional if managed by chronic pain physicians dissociated from any operating room service. It has to be an anesthesiologist run system.

Lastly in all discussion on the pain pathway, the logistics involved, and the extra costs involved, it must not be forgotten that the primary concern is the patient and their best health care.

Mayo clinic is the pioneer in this. Duke Medical Center is another USA university that is center of excellence for arthroplasty regional anesthesia and having formal structured analgesia pathway. One New York centers of arthroplasty excellence have used a pain pathway that has utilized epidural anesthesia only for decades. Their style of extreme hypotensive epidural anesthesia is not supported in most academic circles.

Spinal anesthesia versus TIVA for Hip arthroplasty surgery

A prospective study in 2015 in general, showed more benefits from use of the TIVA general anesthetic compared to bupivacaine spinal anesthesia[67].

9. Thrombo embolism after hip arthroplasty (THR)

It is the leading cause of post-operative death up to 3 months and is responsible for 50% of perioperative deaths. Best method of prophylaxis is controversial. Much study has been done of pharmacological therapy using over-sensitive end points that may not correlate with clinical endpoints. Use of anticoagulants has its own associated morbidity related to the arthroplasty, like bleeding and sepsis.

Therapy is divided into non-pharmacological and pharmacological methods. Spinal anesthesia, and more so, epidural anesthesia seems to reduce thrombo-embolism. Early mobilization does the same. There is a range of opinions about how late it is still beneficial to start pharmacological anti-thrombotic therapy. Calf compression devices have become a norm of practice due to their safety and efficacy.

Some surgeons only use aspirin started from the day before surgery and then re-start the aspirin the day after surgery. Some do the same with coumadin. Some use heparin or even low-molecular weight heparin started the day after surgery. There is little conformity.

It is important to know the practice of the surgeon one is anesthetizing for, as it will alter considerations for neuraxial anesthesia, psoas compartment blocks and even peripheral nerve blocks. It is important to note that regional anesthesia itself may be beneficial too for clot prevention. Earlier mobilization of the patient reduces the DVT risk and neuraxial blocks (particularly epidurals with local anesthetic) may reduce DVT risk. These techniques may induce a surgeon to use a “safer” pharmacological anti-DVT regimen. Lastly it is important to base one’s practice on some advice on interaction between antithrombotic drugs and psoas and epidural nerve blocks. This is itself a controversial area and the extent of self-defensive practice differs in different cultures. Self-defensive practice usually means omission of regional anesthesia regardless of patient considerations.

10. INTRATHECAL MORPHINE.

There are extensive deep theoretical arguments against the use of intrathecal morphine. See another lecture on this topic.

There are however still retrospective studies appearing, as attempts to justify the continued use of intrathecal morphine. The only studies worth examining at this time should be prospective, randomized and controlled studies on this old subject. That aside, Cheah in 2018 published in an open access journal requiring payment of $3050 to publish[68]. That questions the standard of peer review and points to the unlikelihood of article rejection.

Cheah reviewed 598 patients who had undergone hip or knee arthroplasties. Of the group, 467 had received intrathecal morphine. Cheah reported that the only observed difference of statistical significance were; (i) reduction in a 10-point pain scale of pain by only 1 point on the day of surgery in the morphine group, and (ii) a small reduction in required supplementary opiates by 6 morphine equivalents for the full first day of surgery, after the surgery. The Cheah study must be ignored as too much evidence contradicts its solitary outcome, it did not look to the more relevant long-term chronic pain outcomes, and because the study is methodologically severely deficient.

11. CONCLUSION

There is no world gold standard protocol for the use of regional anesthesia on hip arthroplasty patients. Anesthesia practice is very diverse. There are however theoretical and rational arguments favoring use of regional anesthesia, particularly the higher grades of regional anesthesia that this author has highlighted

Accordingly, it is recommended to use an opioid avoidance strategy for all patients undergoing hip arthroplasty, and to center that plan on the use of regional anesthesia. Remember that opioid avoidance does not prohibit using opiates as rescue analgesia after all other therapies are first applied.

Every anesthesia provider should seek to be competent in regional anesthesia. Every anesthesia group should seek to have regional anesthesia experts included in the group. Orthopedic anesthesia should be more strongly recognized as an anesthesia sub-specialty as unique as cardiac-anesthesia, and neuro-anesthesia. Teaching institutions should institute fellowships specifically in orthopedic-anesthesia that includes advanced regional anesthesia training, and such a fellowship would need to be two years duration.

Lastly, Memtsoudis and Kehlet in Feb 2019 condemned the abuse of the term ERAS, (Enhanced Recovery After Surgery) in hip-arthroplasty surgery[69]. The term was evolved 20 years ago in context of abdominal-colonic surgery. It is a vigorously validated patient-centered science specific to only colonic surgery. A shortened length of hospital stays (LOS) was an incidental event, not the target event, as is now extrapolated into orthopedics with total loss of focus on relevant patient long-term outcomes. Orthopedic-LOS is now exploited to maximize the profits of hospitals and drug and device companies. Specifically, the manufacturers of IV acetaminophen and liposomal bupivacaine are blamed. Those companies and the societies they sponsor, extrapolate facts studied in colonic surgery to apply to hip-arthroplasty surgery. The two authors thus infer orthopedic surgery, with anesthesia participation, must return to focusing on specific patient-focused outcomes and do the mandatory vigorous scientific studies before altering time trusted practices over-focused on rushed discharge from hospital.

Good luck!

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