Combination of dexamethasone and bupivacaine versus bupivacaine alone in combined femoral and sciatic nerve block for intraoperative and postoperative analgesia in patients undergoing lower limb vascular surgeries

A thesis submitted for partial fulfillment of

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Abstract

This study demonstrated a significant delay in sensory and motor block regression, in each of the perineural and intravenous dexamethasone groups, and also in the perineural compared to the intravenous dexamethasone group. Duration of analgesia was significantly prolonged in the perineural dexamethasone group, compared to the intravenous dexamethasone and control groups, and also in the intravenous dexamethasone group, compared to the control group. Postoperative pain scores were significantly lower in the perineural dexamethasone group.

Keywords

Dexamethasone

Sensory and motor block

Perineural dexamethasone

Analgesia

Pain scores

Contents

List of Tables

List of Figures

List of Abbreviations

%	g/dl
Å	Angstrom (= 10^{-10} meter)
ANOVA	Analysis of variance
ASA	American Society of Anesthesiologists
ASRA	American Society of Regional Anesthesia and Pain Management
A_{δ}	A-delta fibers
BPB	Brachial Plexus Block
C	Chronaxie
cm	Centimeter
C_{max}	Local anesthetic peak plasma level
CNS	Central Nervous System
COX	Cyclooxygenase
D1 - D4	α-helical domains
DNA	Deoxyribonucleic acid
DRG	Dorsal Root Ganglion
ECG	Electrocardiography
E_K	Equilibrium potential of potassium
E_{Na}	Equilibrium potential of sodium
EU	European Union
FDA	US Food and Drug Administration
Hz	Hertz
IFM	Isoleucine, Phenylalanine and Methionine
IL	Interleukin
I_m	Minimum Intensity
I_r	Rheobase
ISB / ISBPB	Interscalene block / Interscalene brachial plexus block
I_t	Current Intensity
K	Constant
Kg	Kilogram
Kω	Kilomega
L	Lumbar nerve
LA	Local Anesthesia / Local Anesthetic
LANB	Local Anesthetic Neural Blockade
mA	Milliampere
Mg	Milligram
Mg	Milligram
MHz	Megahertz
min	Minute
ml	Milliliter
mM	Millimole
Mm	Millimeter

List of Abbreviations (continued)

Ms	Millisecond
N	Neutral base of tertiary amine local anesthetics
Na_v	Voltage-gated sodium channels
NF-kB	Nuclear Factor kappa-light-chain-enhancer of activated B cells
NH^+	Charged form of tertiary amine local anesthetics
NIBP	Non-invasive Blood Pressure
NRS	Numeric Rating Scale
NS	Nerve Stimulator / Neurostimulation
PACU	Post-anesthesia Care Unit
pK_a	Dissociation constant
PLA_2	Phospholipase A_2
PNB	Peripheral Nerve Block
PNS	Peripheral Nervous System
PONV	Postoperative Nausea and Vomiting
Psi	Pound per Square Inch
PSIS	Posterior superior iliac spine
PVD	Peripheral Vascular Disease
r	Distance
RR	Respiratory rate
S	Sacral nerve
SD	Standard deviation
SpO_2	Pulse oximetery
SPSS	Statistical Package for Social Sciences
t	Time
TTX	Neutral local anesthetic Tetrodotoxin
UN	United Nations
US	Ultrasound
V	Volt
VAS	Visual Analogue Score
VD_{ss}	Volume of Distribution
VRS	Verbal Rating Scale
α	Alpha
µg	Microgram
µm	Micrometer
µs	Microsecond

INTRODUCTION

The past decade has seen a considerable increase in the use of peripheral nerve blocks in anesthesia for a wide range of surgical procedures involving the lower limb. A number of techniques can be used to provide anesthesia, effective pain relief with a low incidence of systemic side effects, which can facilitate improved functional recovery and shortened postoperative hospital stay after major lower limb surgeries. The use of continuous peripheral nerve catheter infusions has superseded epidurals as the analgesic gold standard following some lower limb surgeries such as vascular surgeries; as they can extend analgesia for 48-72 hours postoperatively, avoiding problems associated with block regression and inadequate analgesia that may occur after single injection techniques. As a general rule, proximal sciatic, femoral and lumbar plexus blocks are most suitable for use in an in-patient setting. [1]

Nerve localization in the lower limb is currently achieved using either ultrasound guidance or peripheral nerve stimulation. Ultrasound-guided nerve localization offers several potential advantages when performing femoral, popliteal and distal sciatic nerve block; however, neurostimulation remains a useful and widely used aid to lower limb regional anesthesia practice. [2,3]

Indications of lower limb peripheral nerve blocks include hip surgery such as primary or revision hip arthroplasty or fractured neck of femur surgery, knee surgery such as knee arthroplasty, and vascular surgical procedures or amputations; where they provide multiple benefits in this high risk group of patients, such as cardiovascular stability and decreased opioid requirements, who may also be at risk of significant postoperative pain. [4,5]

Persisting motor block is a recognized side effect of continuous nerve block and some surgeons have concerns because it may delay patient mobilization. When planning pain relief following lower limb surgery however, consideration must be given to the frequent side effects associated with alternative forms of analgesia such as systemic opioids (PONV, sedation and constipation) and the observation that inadequate analgesia can lead to painful restriction of limb movement. [4]

Although lower limb peripheral blocks are frequently used for femoral, ankle and foot surgery, they should probably be avoided in cases where there is a risk of developing compartment syndrome. There is concern that the block will mask pain associated with an evolving compartment syndrome, resulting in delayed diagnosis. Careful patient selection and discussion with surgical colleagues are recommended if there is any uncertainty regarding this risk. [6]

Local anesthetics alone provide analgesia for not more than 4-8 hours. Increasing the duration of local anesthetic action is often desirable because it prolongs surgical anesthesia and analgesia. Different additives have been used to prolong regional blockade. Vasoconstrictors can be used to constrict vessels, thereby reducing vascular absorption of the local anesthetic. Additives like opioids, [7] clonidine and verapamil [8] were added to local anesthetics, but the results are either inconclusive or associated with side effects. Steroids when used intrathecally are reported to cause arachnoiditis, but there is no evidence suggesting any neuritis when steroids are used in low concentration in peripheral nerve blocks. [9]

Steroids have powerful anti-inflammatory as well as analgesic property. Perineural injection of steroids is reported to influence postoperative analgesia. [10,11] They relieve pain by reducing inflammation, and blocking transmission of nociceptive C-fibers and by suppressing ectopic neural discharge. [12] The addition of 5 mg of dexamethasone to 10 ml of 0.5% levobupivacaine in interscalene brachial plexus block showed improvement of postoperative analgesia for arthroscopic shoulder operation without any specific complications. [13]

LUMBAR PLEXUS

Site and mode of formation

It lies within the psoas major muscle, in front of the transverse processes of lumbar vertebrae. It is formed by the anterior primary rami of upper three lumbar nerves ($L_{1,2,3}$) and the greater part of the forth lumbar nerve (L_4). The first lumbar nerve (L_1) receives a contribution from the last thoracic nerve (T_{12}). The rest the forth lumbar nerve with the fifth lumbar nerve form the lumbo-sacral trunk. L_4 is a link between lumbar and sacral plexuses, is termed "nervus furcalis" (Figure 1).

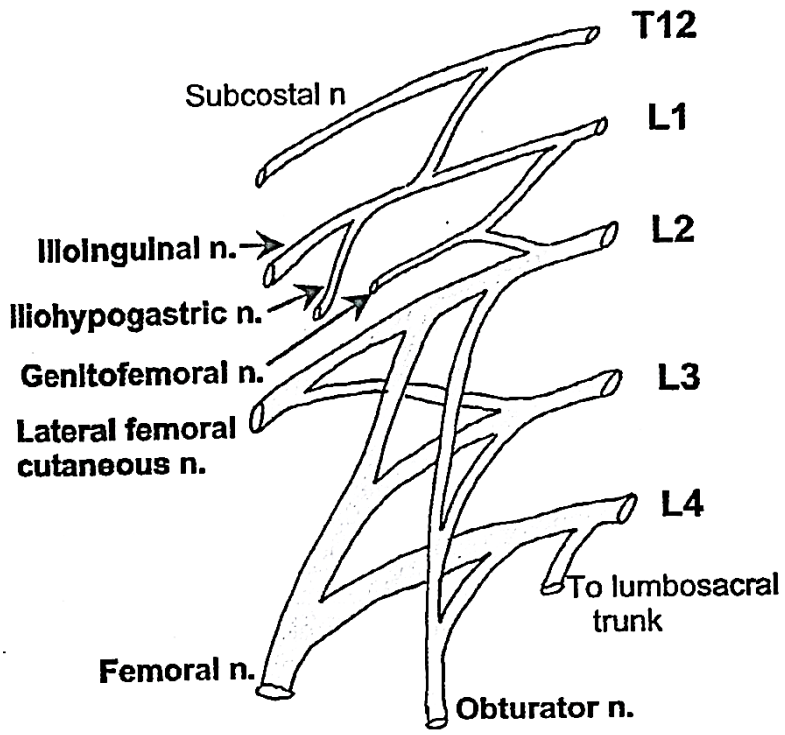

Figure 1 Formation of the lumbar plexus

The usual mode of formation

- The first lumbar nerve (L_1) gives:
  a) Large division: gives iliohypogastric and ilioinguinal nerves.
  b) Small division: joins L_2 nerve to form genitofemoral nerve.
- The second, third and fourth lumbar nerves ($L_{2,3,4}$) divide into ventral and dorsal divisions:
  a) Dorsal divisions of $L_{2,3}$: give the lateral cutaneous nerve of thigh.
  b) Dorsal divisions of $L_{2,3,4}$: give the femoral nerve.
  c) Ventral divisions of $L_{3,4}$: give the accessory obturator nerve (occasional).
  d) Ventral divisions of $L_{2,3,4}$: give the obturator nerve.

Exit of branches of lumbar plexus from the psoas muscle

I. From the front: genitofemoral nerve.
II. From medial aspect (traversing lumbosacral triangle of Marcelle): obturator nerve and lumbosacral trunk.
III. From lateral aspect:
   - Iliohypogastric nerve
   - Ilioinguinal nerve
   - Lateral cutaneous nerve of thigh
   - Femoral nerve (Figure 2)

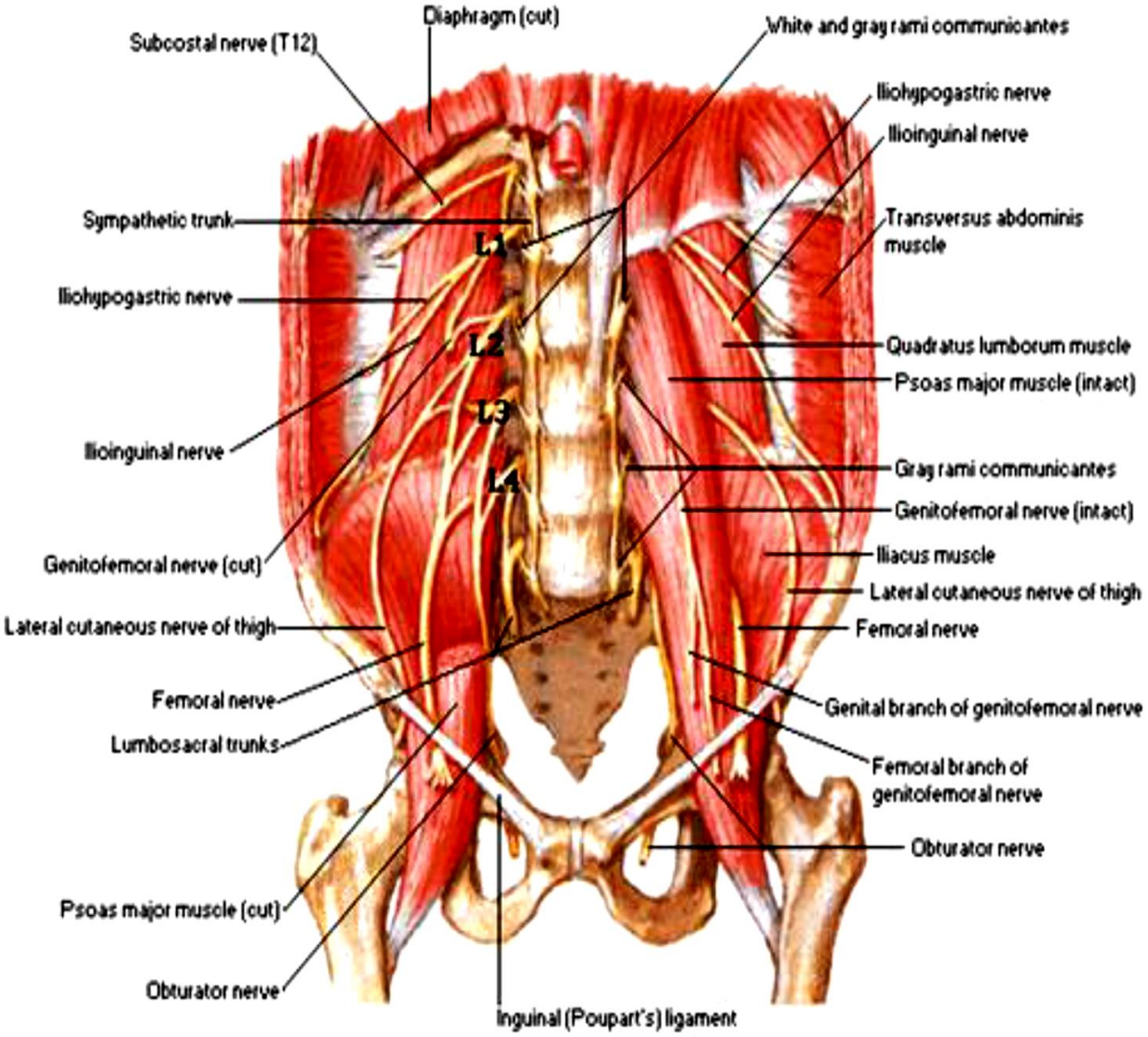

Figure 2 Exit of branches of the lumbar plexus from the psoas muscle

Individual branches of lumbar plexus

1. **Iliohypogastric nerve (L_1):** it emerges from the upper part of the lateral border of psoas major. It passes downwards and laterally between the kidney and quadratus lumborum. Just above the iliac crest, it pierces the fascia transversalis and transversus abdominis muscle, to reach the neuro-muscular plane (between the transversus abdominis and the internal abdominal oblique muscles), where it divides into:
   a) *Lateral cutaneous branch:* pierces the internal and external abdominal obliques above the iliac crest, to supply skin of the side of the buttock.
   b) *Anterior cutaneous branch:* runs between transversus and internal oblique muscles, pierces the latter two centimeters medial to the anterior superior iliac spine, and pierces the external abdominal oblique aponeurosis three centimeters above the superficial inguinal ring, to supply the internal abdominal oblique, transversus abdominis and skin over the symphysis pubis.
2. **Ilioinguinal nerve (L_1):** it emerges from the middle of the lateral border of psoas major (considered a collateral branch of the iliohypogastric nerve taking the same course). Near the anterior part of the iliac crest, it pierces the fascia transversalis and transversus abdominis muscle. Then, it pierces the internal oblique to enter the inguinal canal. Finally, it emerges from the superficial inguinal ring. It supplies internal abdominal oblique, transversus abdominis and skin over the pubis, anterior part of the scrotum and penis in males (labia majora in females) and upper part of medial side of the thigh.
3. **Genitofemoral nerve ($L_{1,2}$):** it emerges from the anterior surface of psoas major muscle and descends in front of it, then it divides into:
   a) *Genital branch (cremasteric nerve):* it enters the deep inguinal ring and supplies skin of the anterior aspect of the external genitalia cremasteric muscle.
   b) *Femoral branch:* it enters the lateral compartment of the femoral sheath, and then it pierces its lateral wall to supply the skin of femoral triangle.
4. **Obturator nerve (ventral divisions of $L_{2,3,4}$):** it passes on the side of the pelvis, accompanied by the obturator artery. It enters the obturator canal, to divide at its end into:
   a) *Anterior division:* passes in front of adductor brevis, behind pectineus and adductor longus muscles and gives:
      - Articular branches: to hip joint.
      - Muscular branches: to adductor longus and brevis, gracilis and pectineus.
      - Cutaneous branches: joins the medial cutaneous nerve of the thigh and saphenous nerve to form the subsartorial plexus of nerves, supplies skin on the medial side of the thigh.
   b) *Posterior division:* pierces obturator externus, descends between it and adductor magnus and gives:
      - Articular branches: to knee joint.

- Muscular branches: to obturator externus, pubic part of adductor magnus and occasionally adductor brevis.

5. **Accessory obturator nerve (ventral divisions of $L_{3,4}$):** to pectineus muscle.
6. **Lateral cutaneous nerve of thigh ($L_{2,3}$):** it descends on the iliacus muscle, then it leaves the abdomen entering the thigh just below and medial to the anterior superior iliac spine. It supplies skin of the lateral side of thigh and gluteal region.
7. **Femoral nerve (dorsal divisions of $L_{2,3,4}$):** descends between psoas major and iliacus to reach the thigh outside the femoral sheath. While still in the abdomen, it gives muscular branches to iliacus and pectineus (its nerve arises deep to the inguinal ligament).
8. **Lumbosacral trunk ($L_{4,5}$):** joins the sacral plexus.

SACRAL PLEXUS

Site and mode of formation

It lies on the posterior wall of the pelvic cavity, in front of piriformis muscle. It is formed by the ventral rami of last two lumbar nerves and first four sacral nerves ($L_{4,5}$,$S_{1,2,3,4}$). The fourth and fifth lumbar nerves (L_4&L_5) form the lumbosacral trunk, which emerges from the medial border of psoas major, then it descends in front of the sacroiliac joint, to join S_1 (Figure 3).

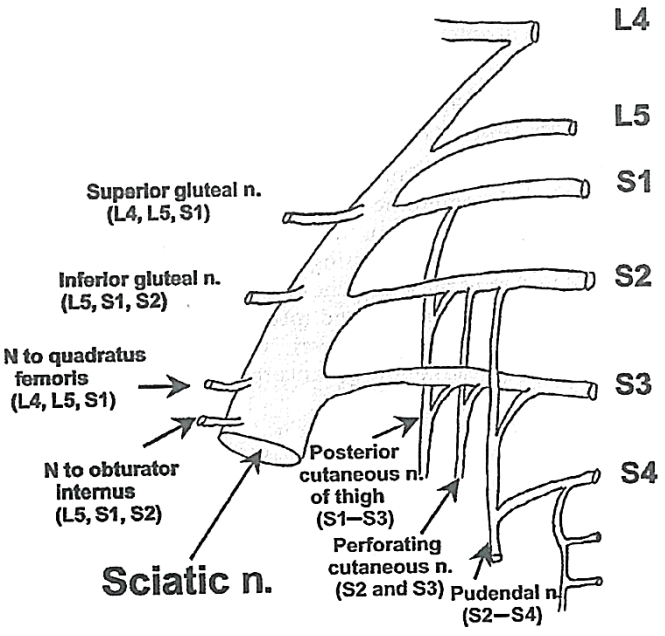

Figure 3 Formation of the sacral plexus

Branches

a) To the pelvic muscles: piriformis, coccygeus and levator ani.

b) To the perineum:

1. *Pudendal nerve:*
   - It is the smaller of the two terminal branches of the sacral plexus.
   - It leaves the pelvis through the lower part of the greater sciatic foramen, below the piriformis, to reach the gluteal region. It crosses the back of sacrospinous ligament (medial to internal pudendal artery), to pass through the lesser sciatic foramen, to enter the posterior end of the pudendal canal. It ends by dividing into the dorsal nerve of penis and the perineal nerve.
   - Braches:
     i. *Inferior rectal nerve:* it arises in the posterior end of the pudendal canal. It traverses the ischiorectal fossa to supply the external anal sphincter and the levator ani.
     ii. *Dorsal nerve of penis* (the smaller of the two terminal branches of pudendal nerve, arising in the pudendal canal): It enters the deep perineal pouch (accompanying the internal pudendal artery), pierces the perineal membrane half an inch behind the symphysis pubis, to reach the superficial perineal pouch. It then accompanies the dorsal artery of penis to run along the dorsum of the penis.
     iii. *Perineal nerve* (the larger of the two terminal branches of pudendal nerve, arising in the pudendal canal): it gives two scrotal (or labial) branches, and then ends dividing into terminal muscular branches to the perineal muscles.
2. *Perineal branch of forth sacral nerve (S_4):* it enters the ischiorectal fossa to supply the external anal sphincter.

c) Pelvic splanchnic nerve ($S_{2,3,4}$): parasympathetic to pelvic organs.

d) To the lower limb:

1. *Sciatic nerve.*
2. *Nerve to quadratus femoris ($L_{4,5}$,S_1):* it leaves the pelvis through the lower part of the greater sciatic foramen, to enter the gluteal region on the anterior surface of sciatic nerve, posterior to the back of ischium. It descends anterior to the obturator internus, the two gemelli and quadratus femoris, to supply quadratus femoris, gemellus inferior muscles and capsule of the hip joint.
3. *Nerve to obturator internus (L_5,$S_{1,2}$):* it leaves the pelvis through the greater sciatic foramen below piriformis, to enter the gluteal region medial to the sciatic nerve. It crosses the back of the root of the ischial spine lateral to the internal pudendal artery. Then, it re-enters the pelvis through the lesser sciatic foramen. It supplies gemellus superior and obturator internus muscles.