

**ANALGESIA AFTER TOTAL HIP REPLACEMENT:
EPIDURAL VERSUS PSOAS COMPARTMENT BLOCK**

by

Johannes Coenraad Bosch

Student no.: 9401385

Submitted for the partial fulfilment of the requirements for the degree
Master of Medicine (Anaesthesiology)

in the

Faculty of Health Sciences
School of Medicine
Department of Anaesthesiology
University of Pretoria

Supervisor: Prof. F. J. Smith

December 2005

DECLARATION

I hereby declare that this research project and dissertation was completed by myself.
It has not been previously submitted at any other university for any degree.

J.C. Bosch

30 December 2005

ACKNOWLEDGEMENTS

I would like to thank the following people:

- The nursing staff at High Care, Orthopaedic Hospital, for the collection of the data.
- Proff. P.J. Bekker and F.J. Smith for the statistical analysis of the data.
- The patients for their willingness to participate.
- Prof. F.J. Smith for his tireless support, guidance and endless patience.
- Prof. A. Milner, Dr T. Dippenaar and Dr A. Glass for proofreading the manuscript.
- My darling wife, Allison, for her love and support.

CONTENTS

Abstract	5
Opsomming	6
Introduction	7
Literature review	8
Method	10
Statistics	14
Results	15
Discussion	18
Conclusion	21
Appendix	22
References	23

ABSTRACT

Introduction

Both epidural anaesthesia and psoas compartment block have been advocated for analgesia after hip replacement. The aim of this study was to evaluate the effectiveness of a psoas compartment block, as compared to an epidural, for postoperative analgesia following total hip replacement surgery.

Method

Patients scheduled for total hip replacement surgery were randomly allocated to one of two groups, one group receiving an epidural, and the other a psoas compartment block preoperatively. An infusion of bupivacaine 0.167% was continued postoperatively for 24h. Postoperative pain was assessed at 0, 1, 4, 8 and 24 hours using the visual analogue pain score (VAPS). The amount of local anaesthesia, need for additional morphine, as well as any side effects, was recorded.

Results

Thirty-six patients completed the study, 18 in each group. There was no significant difference between the two groups regarding VAPS at the different times ($p = 0.4246$), but local anaesthetic and opiate consumption was significantly higher in the psoas compartment block group. Postoperative morphine as co-variate had a significant influence on the mean postoperative VAPS ($p = 0.0066$). There was no significant difference between the number of side effects in each group ($p = 0.3377$).

Conclusion

Epidural analgesia was more effective than the psoas compartment block after hip replacement surgery. Although pain did not differ significantly, local anaesthetic and opiate consumption was significantly higher in the psoas compartment group.

OPSOMMING

Inleiding

Epidurale en psoas kompartement analgesie word in die literatuur aanbeveel vir pynverligting na heupvervangings. Die doel van die studie was om die effektiwiteit van die psoaskompartementblok met dié van 'n epidurale blok te vergelyk, in pasiënte na heupvervangings.

Metode

Pasiënte geskeduleer vir totale heupvervangingschirurgie is gerandomiseer in twee groepe. Die een groep het preoperatief 'n epiduraal gekry, en die ander 'n psoaskompartementblok. 'n Konstante infusie bupivakaïen 0.167% is vir 24 uur na chirurgie toegedien. Pyn is postoperatief by 0, 1, 4, 8 en 24 uur met behulp van die visueel analoë pynskaal (VAPS) bepaal. Die hoeveelheid lokaalverdower, ekstra morfien benodig, en nuwe-effekte is aangeteken.

Resultate

Ses-en-dertig pasiënte het die studie voltooi; 18 in elke groep. Daar was geen beduidende verskil tussen die twee groepe wat betref VAPS by die verskillende tye nie ($p = 0.4246$) maar sowel lokaalverdowervolume as opiaatverbruik was betekenisvol hoër in die psoasgroep. Postoperatiewe morfien as kovariaat het 'n beduidende invloed op die gemiddelde postoperatiewe VAPS gehad. ($p = 0.0066$). Daar was geen beduidende verskil in die voorkoms van nuwe-effekte in die groepe nie ($p = 0.3377$).

Gevolgtrekking

Epidurale analgesie was na heupvervangingschirurgie meer effektief as die psoaskompartementblok. Alhoewel pyn nie beduidend verskil het nie, was sowel lokaalverdower as opiaatverbruik betekenisvol hoër in die psoaskompartement groep.

INTRODUCTION

Epidural anaesthesia has been advocated as an effective form of postoperative analgesia in patients undergoing hip replacement surgery.¹ Epidural block is however not without risk. Complications include backache, headache, urinary retention, systemic toxicity, neurological deficit, infection and epidural haematoma.² Due to stringent contraindications, patients are often excluded.

The psoas compartment block (lumbar paravertebral block) has also proven useful for postoperative analgesia after hip replacement,¹ and has been advocated as an alternative to epidural block. It is not entirely without risk either. Complications include nerve injury,³ intravascular injection, subarachnoidal or epidural injection, psoas compartment haematoma, intra-abdominal injury and pain due to spasm of the lumbar paravertebral muscles.⁴ However, contraindications are less stringently applied, especially with regard to bleeding disorders and anticoagulation therapy. Consequently, fewer patients are excluded. The procedure is also easier to perform.¹²

The aim of this study was to evaluate the effectiveness of a psoas compartment block, as compared to an epidural block, for postoperative analgesia after total hip replacement.

LITERATURE REVIEW

The posterior approach to the lumbar plexus was first described by Winnie et al.⁵ Subsequently Chayen et al. employed the block successfully for hip replacement surgery.⁶ They were the first to call this approach the ‘psoas compartment block’. Dekrey described (not published) a posterior approach to the lumbar plexus in which the local anaesthetic solution is injected directly into the posterior part of the psoas muscle (‘psoas sheath block’). Parkinson et al. modified this approach by using a nerve stimulator.⁷

Several studies have proved the effectiveness of regional analgesia after major hip surgery. Capdevila et al. proposed new landmarks and technical guidelines for psoas compartment block, and found it to give optimal analgesia after hip replacement surgery, with few side effects.⁸

Several studies concluded that surgical analgesia (requiring a more dense block) is achievable using a psoas compartment block, usually combined with a sciatic nerve block. Ho et al. used this approach in a patient with severe aortic stenosis for reduction of a hip fracture.⁹ Buckenmaier et al. used it for total hip replacement surgery.¹⁰ However, Adams et al. found that the surgical stress response is better controlled after epidural anaesthesia than after a psoas block. This led him to rather recommend epidural anaesthesia, especially in patients with ischaemic heart disease.¹¹

Regarding partial hip replacement, Turker et al. found that continuous psoas compartment block provides excellent intra- and postoperative analgesia, with a low incidence of complications. In that study the psoas compartment block was compared to epidural block – the only study of its kind that could be found in the literature. It was found that the epidural required significantly more attempts than the psoas compartment block, thus increasing the procedure time and potentially the complication rate. It was also found that the epidural group had significantly more complications, mainly haemodynamic instability requiring treatment with adrenaline.¹² In our opinion the epidural dose of 15 ml of 0.5% bupivacaine (epidural catheter inserted at L3-L4 threaded 3 cm cephalad) may be excessive, especially in

the elderly. In addition, the 30ml 0.5% bupivacaine used for the psoas compartment block might have approached the toxic dose.

The inguinal paravascular (“3-in-1”) block gives neurotomal and dermatomal fallout very similar to the psoas block, but the approach differs. Two studies compared continuous epidural block with a continuous “3-in-1” block for pain relief after arthroplasty. Singelyn et al. found that “3-in-1” blockade gives comparable pain relief to epidural block after knee replacement surgery, and that the “3-in-1” block is the technique of choice due to a better risk profile.¹³ In a later study, Singelyn et al. found the same results in a study on hip replacement surgery.¹⁴

A comparison of psoas compartment block and the “3-in-1” block suggested that psoas compartment block is more effective than the “3-in-1” block.¹⁵ Anatomical variations (existence of an accessory obturator nerve) may account for this difference.¹⁷

Although the psoas block seems to be safe and effective, it has not gained widespread acceptance. Bogogh et al. found no significant difference between morphine PCA and PCA with psoas block.¹⁶

METHOD

The study was performed on patients undergoing total hip replacement surgery at Pretoria Academic and Kalafong Hospitals in Pretoria, South Africa. The study protocol was approved by the ethics committee of the University of Pretoria. Adult male and female patients of all ages were included. Informed consent was obtained from all patients. Patients who refused a regional procedure, had any contraindication to neuraxial blocks or underwent bilateral arthroplasty were excluded from the study.

Patients were randomly allocated to two groups. Patients in group E had an epidural catheter and patients in group P a psoas compartment catheter, placed preoperatively. The epidural puncture site was the L4 – L5 interspace, and a catheter was threaded 5 cm cephalad after loss of resistance to saline.

For the psoas compartment block, a modification of the technique described by Parkinson et al. was used.^{a 7} (Figures 1 – 4) The needle was placed 3 cm from the midline, on the level of the superior border of the L2 spinous process. After contact with the transverse process, the needle was redirected caudally to “walk off” the transverse process. The psoas compartment was identified by loss of resistance. The catheter was threaded approximately 3 cm.

After precautions were taken to assure correct catheter placement (aspiration before injection as well as a test dose), the block was started preoperatively in both groups. In group E, correct catheter *tip* position was confirmed with the test dose (catheter tip was assumed to be anatomically in the middle of the sensoric dermatomal fallout after the test dose). A dose of 1ml/dermatome 0.25% bupivacaine was administered via the catheter in 2-3ml increments. In group P, 40ml of a 0.25% bupivacaine solution was administered via the catheter. In both groups the aim was to have maximal anaesthesia over the L2 dermatome.

A general anaesthetic was administered in both groups after local anaesthesia was demonstrated in the correct dermatomal distribution. During surgery, a continuous

^a Personal communication, Dr Robert Raw, Regional Anaesthesia and Pain Therapy of South Africa (RAPSA), Hands-on Animal Regional Anaesthesia Workshop, 2003

infusion of bupivacaine 0.167% was commenced. For the group E patients, a continuous infusion of bupivacaine at 0.1 ml/kg lean body mass/h was started. Patients in group P received 10 ml/h, the same amount used by Turker et al.¹², and within the limits proposed by Jankovic and Wells.⁴ Intravenous morphine was administered as deemed necessary.

Postoperatively, the need for additional analgesia was determined. If necessary, the patient received additional local anaesthetic via the epidural or psoas compartment catheter. If pain control was still ineffective, intravenous morphine was titrated in 1mg boluses until the patient was pain free. The patient was then discharged to a high care unit, where an infusion of bupivacaine 0.167% was continued for a period of 24 hours postoperatively. Additional analgesia, in the form of morphine in 1mg boluses, was administered if pain control was ineffective.

The visual analogue pain score (VAPS) was assessed directly postoperatively (0 hours), and then again at 1, 4, 8 and 24 hours. A 100 mm Visual Analogue Pain Scale (Appendix) was used, substituted with a verbal descriptive pain scale (VDPS) for patients who did not seem to understand the former, or who had visual impairment. (No pain = 0, Mild pain = 25, Moderate pain = 50, Severe pain = 75, Intolerable pain = 100)

The need for additional analgesia (morphine in mg), as well as side effects, were recorded. All data was documented by the sister caring for the patient in high care, who was blinded as to the nature of the block.

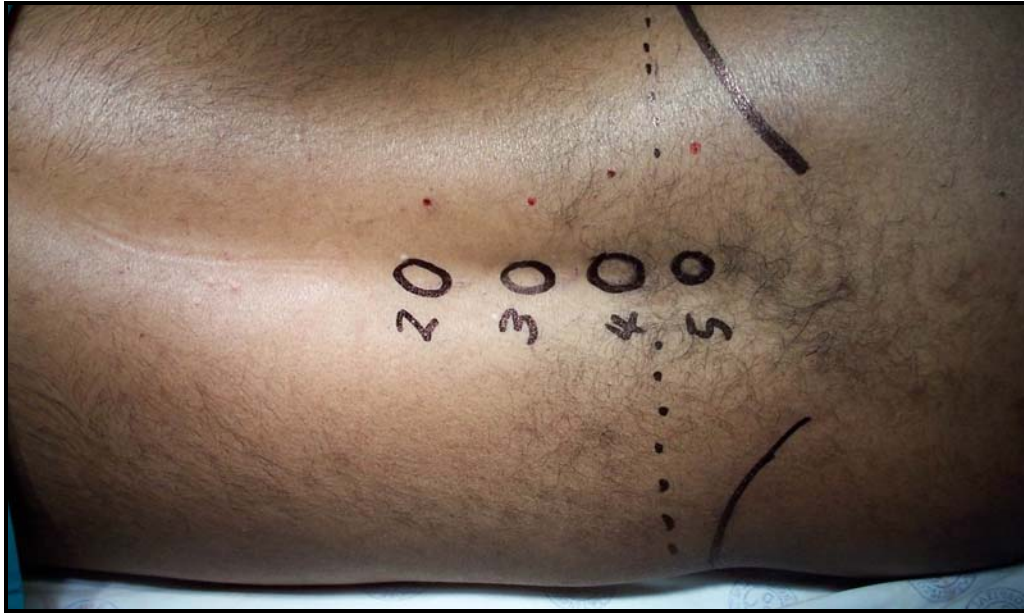


Figure 1: Landmarks: *Spinous processes L2-L5 with injection points lateral*



Figure 2: Placement of needle: *in this figure 4cm lateral to L4; for hip surgery needle placement 3cm lateral to L2*



Figure 3: Loss of resistance to saline for identification of psoas compartment



Figure 4: Injection of local anaesthetic

STATISTICS

In this equivalence study a sample size of 18 per group provided power in excess of 80% when an equivalence delta of 10% was used (25 per group will provide power in excess of 90%). A standard deviation of 11.7 on the VAPS was employed, which was derived from the pain range of 15 – 85% on the VAPS. Equivalence was assumed when the absolute confidence limits of the 95% confidence interval for the difference between the mean visual analogue scale pain scores of the two groups were less than 10 points on the VAPS.

Continuous data is reported as mean (SD). For the VAPS the 95% confidence interval (95% CI) is given. Data was analyzed with Statistix8 software. Continuous data was analyzed with analysis of variance for repeated measures (ANOVA). Individual data points were compared with the two-sample t-test. Categorical data was analyzed with the two-sided Fisher exact test. P values of < 0.05 were regarded as significant.

RESULTS

Thirty-six patients completed the study; 18 in group E and 18 in group P. Data is summarized in Table 1. There was no significant difference between the two groups regarding VAPS at the different times ($p = 0.4246$; ANOVA); the mean VAPS also did not differ significantly ($p = 0.4248$). The frequency of the different VDPS during the first 24 hours did not differ significantly ($p = 0.5007$; χ^2 test).

Although the pain experienced in the two groups did not differ significantly, the two techniques are not equivalent as the 95% CI of the difference between pain scores at the different time points were $> |10$ points|.

The intra- ($p < 0.0001$) and postoperative ($p = 0.0002$) volume of bupivacaine solution as well as the need for additional intra- ($p = 0.0007$) and postoperative ($p = 0.0217$) morphine was significantly higher in Group P than in Group E (Figures 5 and 6).

If intraoperative and postoperative morphine doses were included into ANOVA as covariates, postoperative morphine had significant influence on the mean postoperative VAPS ($p = 0.0066$), whereas intraoperative morphine had no significance ($p = 0.5011$). Intraoperative bupivacaine administration approached significance ($p = 0.0603$).

Table 1: Summary statistics

Variable	Group E	Group P	95% CI of difference	p*
Age	66.8 (11.0)	59.8 (12.3)	-0.9; 14.9	0.0806
Bupivacaine 0.25% intraoperative (ml)	16.8 (6.4)	63.3 (12.4)	-53.2; -39.8	<0.0001
Bupivacaine 0.167% postoperative (ml)	181.2 (41.0)	231.1 (29.3)	-74.0; -25.9	0.0002
Morphine intraoperative (mg)	2.8 (3.1)	7.1 (3.8)	-6.7; -2.0	0.0007
Morphine postoperative (mg)	5.8 (5.8)	12.6 (10.2)	-12.4; -1.1	0.0217
VAPS0	0 (0)	8.3 (24.3)		0.1630
VAPS1	5.6 (13.7)	16.7 (25.2)	-25.0; 2.8	0.1123
VAPS4	20.8 (26.1)	16.7 (21.3)	-12.0; 20.3	0.6030
VAPS8	22.5 (25.6)	28.1 (27.2)	-23.5; 12.4	0.5327
VAPS24	26.4 (25.0)	25.6 (21.8)	-15.1; 16.7	0.9157
Mean VAPS	15.1 (13.6)	19.1 (16.0)	-14.1; 6.1	0.4248

*Two-sample t test; VAPS0, VAPS1, VAPS4, VAPS8, VAPS24 are the visual analogue pain count directly postoperatively, and at 1, 4, 8, and 24 hours respectively. VAPS is the mean VAPS during the first postoperative 24 hours.

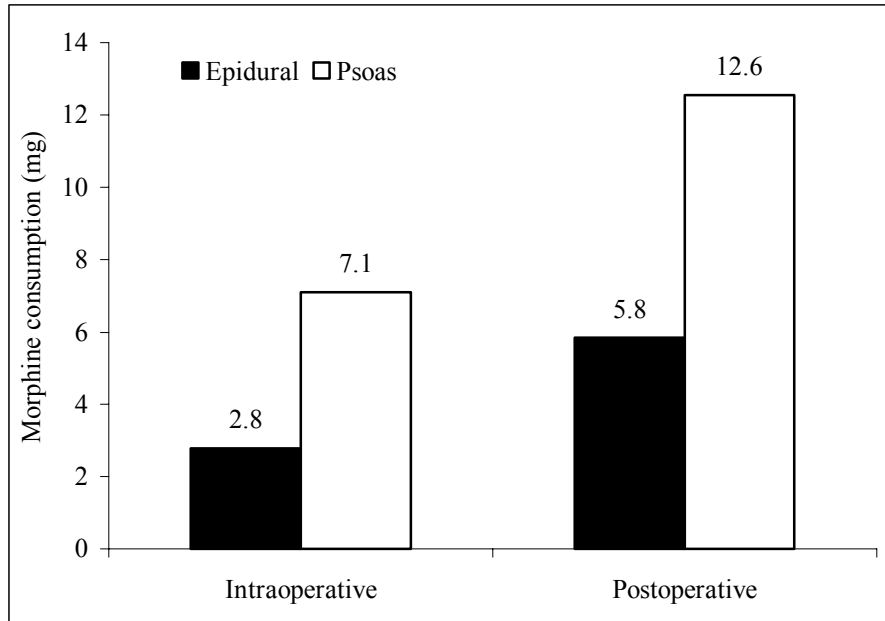


Figure 5: Intra-and postoperative morphine consumption

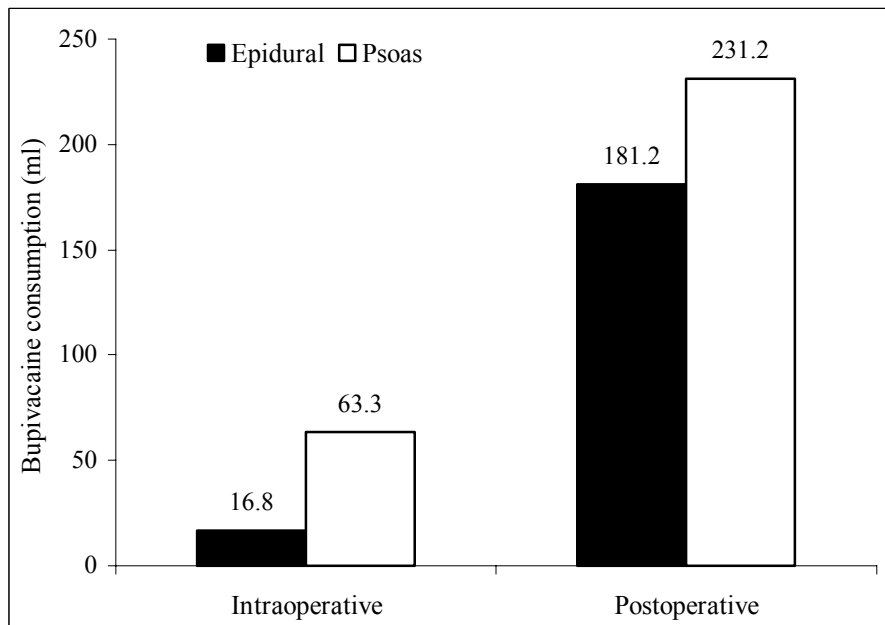


Figure 6: Intra-and postoperative bupivacaine consumption

The pain experienced at the different times differed significantly ($p < 0.0001$). There was no interaction between time and groups. Patients experienced the most pain from 4 to 24 hours; pain was significantly less at 1 hour and the least immediately postoperative (Table 2).

Table 2: VAPS at different times

Time postoperatively (hour)	VAPS	Rank
0	4.2	C
1	11.1	BC
4	18.8	AB
8	25.3	A
24	26.0	A

The number of side effects was 4/18 in Group E and 1/18 in Group P ($p = 0.3377$, Fisher exact test).

DISCUSSION

This study demonstrates the superiority of epidural analgesia over that of psoas compartment block for postoperative pain relief following hip replacement surgery. The average scores on the visual analogue pain scale for both procedures were comparable, but local anaesthetic and opiate consumption was significantly higher in the psoas compartment block group.

Postoperative morphine use as covariate had significant influence on the mean postoperative VAPS, whereas the influence of intraoperative bupivacaine use as covariate was approaching significance. This increased need places the patients in the psoas compartment block group at a higher risk for local anaesthetic toxicity and opiate side effects.

Four out of 18 patients in the epidural group experienced a drop in blood pressure requiring treatment, while no patient in the psoas compartment group demonstrated any haemodynamic instability. The reason for this is that there is less sympathetic blockade when blocking the lumbar somatic plexus, as compared to neuraxis blocks, often with extensive sympathetic block leading to decreased afterload and blood pressure.¹² There is a small risk of epidural spread with the psoas compartment block.⁴ The psoas compartment block may therefore be more suited for a patient with cardiovascular instability. A few patients in the epidural group complained of the numbness in their legs, one of them finding it intolerable.

There were a number of factors noted during the study that may have contributed to the psoas compartment block not being as effective as an epidural (higher morphine consumption):

1. Patients requiring hip replacement surgery frequently have bilateral hip joint pathology. An epidural provides effective analgesia to both hip joints. It was noted that patients with a psoas compartment block often experienced pain in the contralateral joint due to positioning post operatively (abduction of hips to prevent dislocation of the prosthesis). This can partially explain the increased use of opiates in this group.

2. A large volume of local anaesthetic is required to block the entire lumbar plexus with a psoas compartment block. This often necessitates the dilution of the local anaesthetic to stay below the toxic dose. Consequently the quality of the block may decrease. This is in sharp contrast to an epidural for which volume constraints are not usually an issue.

3. In an anatomical study of the lumbar somatic plexus, Sim and Webb found anatomical variations in the formation of the lumbar plexus in over 40% of the 60 plexuses studied by cadaveric dissection. Most of these variations were trivial, but in 12% an accessory obturator nerve was present. The accessory obturator nerve (arising from the anterior divisions of the L3 and L4 nerve roots, and supplying the hip joint when present) does not lie in close approximation to the obturator nerve. They concluded that this anatomical variation should be considered as a possible reason for inadequate block, especially in hip surgery.¹⁷

4. In the same study, Sim and Webb demonstrated that the lumbar plexus lies within the psoas muscle substance. This suggests that the psoas compartment provides indirect access to the lumbar plexus, and that injecting local anaesthetic directly into the psoas major muscle might improve efficacy.¹⁷ It must be noted that the loss of resistance when reaching the psoas compartment is indistinguishable from that within the muscle itself, and more subtle than loss of resistance when reaching the epidural space. In the author's opinion, exact needle tip position cannot be assumed clinically, and injection of a local anaesthetic solution when aiming for the compartment may well be into the muscle itself. This corresponds with an observation made by Capdevila et al. They demonstrated with radiological studies that the catheter tip lay within the psoas major muscle in 74% of patients, and between the psoas and quadratus lumborum muscles (psoas compartment) in 22% of patients.⁸

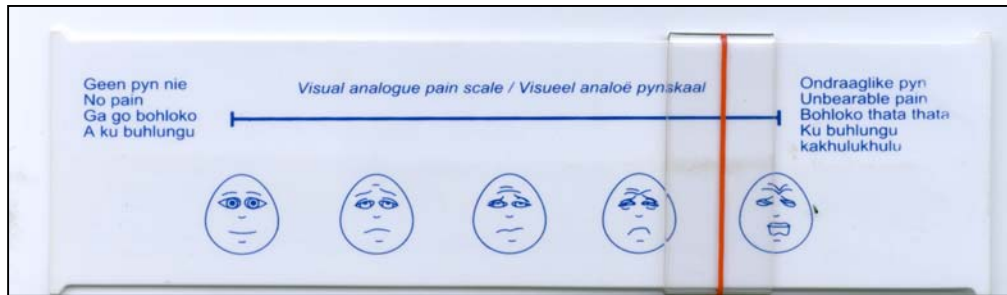
Certain recommendations can be considered to improve the quality of a psoas compartment block:

1. Patient controlled epidural analgesia (PCEA) is associated with less local anaesthetic consumption, more effective pain relief and improved patient acceptance.¹⁸ One reason for this is that bolus injections spread more extensively than a continuous infusion.¹⁹ Similarly, patient controlled peripheral analgesia leads to better analgesia and lower opiate consumption.¹⁸ The implementation of a patient controlled psoas compartment block may prove to provide more effective analgesia at lower volumes of local anaesthetic.
2. Kirchmair et al. performed ultrasound guided psoas compartment needle placements on cadavers. This enabled the needle to be placed correctly in 98% of cases.²⁰ Despite this good result, the lumbar plexus is a deep structure that is difficult to visualise with ultrasound and this technique requires additional investigation in a clinical setting. Further development of ultrasound-guided placement of psoas compartment blocks may well improve the success rate and quality of the block, decrease the amount of local anaesthetic required and minimise complications.²¹
3. A multimodal approach allows for optimal postoperative pain relief. To decrease local anaesthetic consumption and improve analgesia, an opiate may be mixed with the local anaesthetic solution. The addition of systemic paracetamol and NSAIDs should always be considered.¹⁸
4. Instead of using a fixed concentration of bupivacaine (0.25%), the maximum dosage can be calculated (i.e. 2mg/kg), and this amount of bupivacaine 0.5% is then diluted with saline to 40 ml. This approach provides a higher concentration of bupivacaine in all patients weighing more than 50 kg, and should lead to a higher quality of block.^a

CONCLUSION

Epidural analgesia has proved to be more effective than the psoas compartment block in providing analgesia for patients after hip replacement surgery. The average scores on the visual analogue pain scale for both procedures were comparable, but local anaesthetic and opiate consumption was significantly higher in the psoas compartment block group. Despite its shortcomings, a psoas compartment block should always be considered in a patient with absolute or relative contraindications to epidural analgesia.

APPENDIX



REFERENCES

-
- ¹ Sharrock NE, Beckman JD, Inda EC, Savarese JJ, Anesthesia for Orthopedic Surgery In: Miller RD (Ed), Miller's Anesthesia, Elsevier Churchill Livingstone, Philadelphia, Pennsylvania, 2005; 2409-2434
- ² Brown DL, Spinal, Epidural, and Caudal Anesthesia in: Miller RD (Ed), Miller's Anesthesia, Elsevier Churchill Livingstone, Philadelphia, Pennsylvania, 2005; 1653-1683
- ³ Al-Nasser B, Palacios JL, Femoral Nerve Injury Complicating Continuous Psoas Compartment Block, Regional Anesthesia and Pain Medicine 2004; 29: 361-363
- ⁴ Jankovic D, Wells C, Regional Nerve Blocks, Blackwell Science, Berlin, Vienna, 2001; 160
- ⁵ Winnie AP, Ramamurthy S, Durrani Z, Radonjic R, Plexus Blocks for Lower Extremity Surgery, Anesthesiology 1974; 1: 11-16
- ⁶ Chayen D, Nathan H, Chayen M, The Psoas Compartment Block, Anesthesiology 1976; 45: 95-99
- ⁷ Parkinson SK, Mueller JB, Little WL, Baily SL, Extent of Blockade With Various Approaches to the Lumbar Plexus, Anesthesia and Analgesia, 1989; 68: 243-248
- ⁸ Capdevila X, Macaire P, Dadure C, Choquet O, Biboulet P, Ryckwaert Y, D'athis F, Continuous Psoas Compartment Block for Postoperative Analgesia After Total Hip Arthroplasty: New Landmarks, Technical Guidelines, and Clinical Evaluation, Anesthesia and Analgesia., 2002; 94(6): 1606-1613
- ⁹ Ho AM, Karmakar MK, Combined Paravertebral Lumbar Plexus and Parasacral Sciatic Nerve Block for the Reduction of Hip Fracture in a Patient With Severe Aortic Stenosis, Canadian Journal of Anaesthesia, 2002; 49(9): 946-950
- ¹⁰ Buckenmaier CC 3rd, Xenos JS, Nilsen SM, Lumbar Plexus Block With Perineural Catheter and Sciatic Nerve Block for Total Hip Arthroplasty, Journal of Arthroplasty, 2002; 17(4): 499-502
- ¹¹ Adams Ha, Saatweber P, Schmidz CS, Hecker H, Postoperative Pain Management in Orthopaedic Patients: No Differences in Pain Score, But Improved Stress Control by Epidural Anaesthesia, European Journal of Anaesthesiology, 2002; 19(9): 658-665
- ¹² Turker G, Uckunkaya N, Yavascaoglu B, Yilmazlar A, Ozcelik S,. Comparison of the Catheter-Technique Psoas Compartment Block and the Epidural Block for Analgesia in Partial Hip Replacement Surgery, Acta Anaesthesiologica Scandinavica, 2003; 47(1): 30-36
- ¹³ Singelyn FJ, Deyaert M, Joris D, Pendeville E, Gouverneur JM, Effects of Intravenous Patient-Controlled Analgesia With Morphine, Continuous Epidural Analgesia, and Continuous Three-In-One Block on Postoperative Pain and Knee Rehabilitation After Unilateral Total Knee Arthroplasty, Anesthesia and Analgesia, 1998; 87(1): 88-92

-
- ¹⁴ Singelyn FJ, Gouverneur JM, Postoperative Analgesia After Total Hip Arthroplasty: I.V. PCA With Morphine, Patient-Controlled Epidural Analgesia, or Continuous '3-in-1' block?: A Prospective Evaluation by Our Acute Pain Service in More Than 1300 Patients, *Journal of Clinical Anesthesia*, 1999; 11(7): 550-554
- ¹⁵ Tokat O, Turker YG, Uckunkaya N, Yilmazlar A, A Clinical Comparison of Psoas Compartment and Inguinal Paravascular Blocks Combined With Sciatic Nerve Block, *Journal of International Medical Research* , 2002; 30(2): 161-167
- ¹⁶ Bogoch ER, Henke M, Mackenzie T, Olschewski E, Mahomed NN, Lumbar Paravertebral Nerve Block in the Management of Pain After Total Hip and Knee Arthroplasty: A Randomized Controlled Clinical Trial, *Journal of Arthroplasty*, 2002; 17(4): 398-401
- ¹⁷ Sim IW, Webb T, Anatomy and Anaesthesia of the Lumbar Somatic Plexus, *Anaesthesia and Intensive Care*, 2004; 32: 178-187
- ¹⁸ Wu CL, Acute Postoperative Pain In: Miller RD (Ed), *Miller's Anesthesia*, Elsevier Churchill Livingstone, 2005;2729-2762
- ¹⁹ Kaynar AM, Shankar KB, Epidural infusion: continuous or bolus?[comment], *Anesthesia and Analgesia*, 1999; 89(2): 534
- ²⁰ Kirchmair L, Entner T, Kapral S, Mitterschiffthaler G, Ultrasound Guidance for Psoas Compartment Block: An Imaging Study, *Anesthesia and Analgesia*, 2002; 94: 706-710
- ²¹ Marhofer P, Greher M, Kapral S, Ultrasound Guidance in Regional Anaesthesia, *British Journal of Anaesthesia*, 2005; 94(1): 7-17