Analgesia after total hip replacement: epidural versus psoas compartment block

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ABSTRACT

Background

The objective of this paper is to evaluate the effectiveness of a psoas compartment block, as compared with an epidural, for postoperative analgesia following total hip replacement surgery. The research design was a double-blinded randomised control trail, in the setting of a university hospital.

Methods

Patients scheduled for hip arthroplasty received either a psoas compartment or epidural infusion of bupivacaine. The outcome measures that were examined were
postoperative pain, local anaesthetic and morphine consumption, and side effects.

Results

There was no significant difference between the two groups regarding postoperative pain. Local anaesthetic and opiate consumption was significantly higher in the psoas compartment block group. Postoperative morphine as covariate had a significant influence on the mean postoperative pain. There was no significant difference between side effects in each group.

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.

Introduction

Epidural anaesthesia has been advocated as an effective form of postoperative analgesia in patients undergoing hip replacement surgery.[1] Epidural block is not without risk, however. 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, and has been advocated as an alternative to epidural block.[1] It is not entirely without risk either. Complications include nerve injury,[3] intravascular injection, subarachnoid 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. The procedure is also easier to perform.[5]

The posterior approach to the lumbar plexus was first described by Winnie *et al.*[6] Subsequently, Chayen *et al*. employed the block successfully for hip replacement surgery.[7] 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.[8]

Capdevila *et al.* proposed new landmarks and technical guidelines for the psoas compartment block and found it to give optimal analgesia after hip replacement surgery, with few side effects.[9]

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 for the reduction of a hip fracture in a patient with severe aortic stenosis.[10] Buckenmaier et al. used it for total hip replacement surgery.[11] However, Adams *et al.* found that the surgical stress response is controlled better after epidural anaesthesia than after a psoas block. This led them to rather recommend epidural anaesthesia, especially in patients with ischaemic heart disease.[12]

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 with 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.[5] They administered a bolus of 15 ml of 0.5% bupivacaine (epidural catheter inserted at L3-L4 threaded 3 cm cephalad). In our opinion, the dose of bupivacaine is within recommended safety limits. However, the volume of 15 ml may be excessive,

especially when given as a bolus and in the elderly. In addition, the 30 ml 0.5% bupivacaine used for the psoas compartment block may approach the toxic dose.

The inguinal paravascular ("3-in-1") block gives neurotomal and dermatomal fallout very similar to that of 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 the "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] An accessory obturator nerve may account for this difference.[16] 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.[17]

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.

Method

The study was performed on patients undergoing total hip replacement surgery at Pretoria Academic and Kalafong Hospitals in Pretoria, South Africa. The ethics committee of the University of Pretoria approved the study protocol. Adult male and female patients of all ages were included. Informed consent was obtained from all of the 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 received a psoas compartment catheter, placed preoperatively. The epidural puncture site was the L4 to L5 interspace, and a catheter was threaded 5 cm cephalad after loss of resistance to saline.

Figure 1: Landmarks: spinous processes L2 to L5 with injection points lateral.

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

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

Figure 4: Injection of local anaesthetic through the catheter.

For the psoas compartment block, a modification of the technique described by Parkinson et al. was used (Personal communication, Dr Robert Raw, Regional Anaesthesia and Pain Therapy of South Africa (RAPSA), Hands-on Animal Regional Anaesthesia Workshop, 2003).[8] The needle was placed 3 cm from the midline at 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 (Figures 1 to 4).

In Group P, intravascular placement of the catheter was excluded by the injection of a test dose and aspiration before injection of 40 ml of a 0.25% bupivacaine solution. In Group E, the correct catheter tip position was confirmed with a test dose before a dose of 1 ml/dermatome 0.25% bupivacaine was administered. In both groups the aim was to have maximal anaesthesia over the L2 dermatome. The block was started preoperatively in both groups.

A "standard" general anaesthetic was administered in both groups after local anaesthesia was demonstrated in the correct dermatomal distribution. During surgery, a continuous infusion of bupivacaine 0.167% was commenced. In Group E 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*.[5], and within the limits proposed by Jankovic and Wells.[4] Morphine was administered as deemed necessary.

The need for additional analgesia was determined postoperatively. 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 1 mg boluses until the patient was pain free. Patients were discharged to a high care unit, where an infusion of bupivacaine 0.167% was continued for a period of 24 hours postoperatively. Morphine in 1 mg 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 was used. The need for additional analgesia (morphine in mg), as well as side effects, was recorded. All data were documented by the sister caring for the patient in high care. The sister caring for the patient and the patient were blinded as to the nature of the block.

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 to 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 was less than 10 points on the VAPS.

Continuous data are reported as mean (SD). For the VAPS, the 95% confidence interval (95% CI) is given. Data were analysed with Statistix version 8 software. Continuous data were analysed with analysis of variance for repeated measures (ANOVA). Individual data points were compared with the two-sample t-test. Categorical data were analysed 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. The data are summarised in Table I. There was no significant difference between the two groups regarding VAPS at the different times ($p = 0.4246$; ANOVA).

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 was $> |10$ 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 in ANOVA as covariates, the postoperative morphine dose had a significant influence on the mean postoperative VAPS ($p = 0.0066$), whereas intraoperative morphine had no significance influence ($p = 0.5011$). The influence of intraoperative bupivacaine administration approached significance ($p = 0.0603$).

Table I: 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	NS
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)		NS
VAPS1	5.6 (13.7)	16.7 (25.2)	-25.0; 2.8	NS
VAPS4	20.8 (26.1)	16.7 (21.3)	-12.0; 20.3	NS
VAPS8	22.5 (25.6)	28.1 (27.2)	-23.5; 12.4	NS
VAPS24	26.4 (25.0)	25.6 (21.8)	-15.1; 16.7	NS
Mean VAPS	15.1 (13.6)	19.1 (16.0)	-14.1; 6.1	NS

VAPS0, VAPS1, VAPS4, VAPS8, VAPS24 are the visual analogue pain scores directly postoperatively, and at 1, 4, 8, and 24 hours respectively. VAPS is the mean VAPS during the first postoperative 24 hours. NS - not significant

Figure 5: Intra-and postoperative morphine consumption.

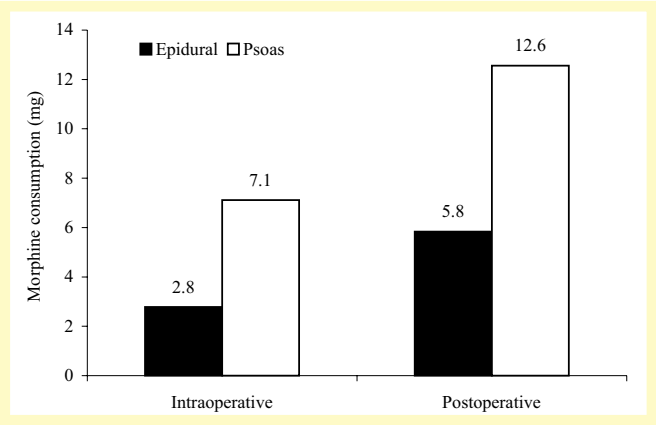
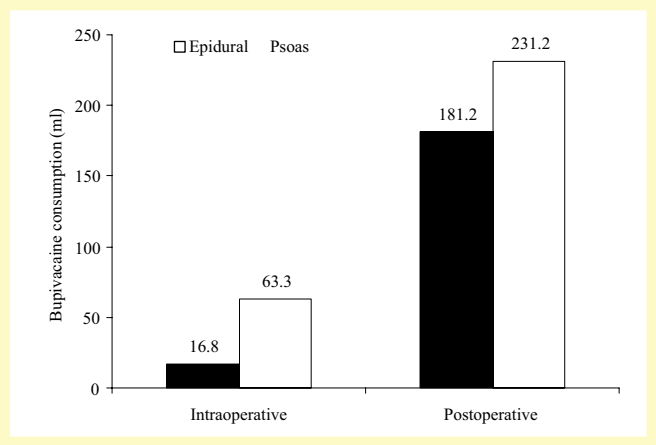


Figure 6: Intra-and postoperative bupivacaine consumption.



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 four to 24 hours; pain was significantly less at one hour and the least immediately postoperatively. Hypotension necessitating treatment by the nursing staff occurred in three of the patients in Group E, but in none in Group P. The difference was not significant ($p = 0.2286$).

Discussion

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

Postoperative morphine consumption as covariate had significant influence on the mean postoperative VAPS. These increased doses of bupivacaine placed the patients in the psoas compartment block group at a higher risk for local anaesthetic toxicity and opiate side effects.

Three out of 18 patients in Group E experienced a drop in blood pressure that required treatment, whilst no patient in the psoas compartment group demonstrated any haemodynamic instability. In this small sample size the difference was not significant. The fall in blood pressure in the three patients in Group E can be explained by sympatholysis, which was not observed in Group P.[5] The psoas compartment block may therefore be more suited for a patient with cardiovascular instability. There is, however, a small risk of epidural spread with the psoas compartment block.[4]

In this study, the psoas compartment block was inferior to the epidural block. Several factors could contribute to this finding. These aspects should be taken into account when performing these blocks. Firstly, 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 postoperatively (abduction of hips to prevent dislocation of the prosthesis).

Secondly, patient-controlled epidural analgesia is associated with less local anaesthetic consumption, more effective pain relief and improved patient acceptance.[18] One reason for this is that boluses injected epidurally spread more extensively than a continuous infusion.[19] Similarly, patient-controlled peripheral (nerve or plexus) analgesia leads to better pain relief and lower opiate consumption.[18] Therefore, implementation of a patient-controlled psoas compartment block may prove to provide more effective analgesia at lower volumes of local anaesthetic.

Thirdly, 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. Instead of using a fixed concentration of bupivacaine (0.25%), the maximum dosage can be calculated (i.e. 2 mg/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. (Personal communication, Dr Robert Raw, Regional Anaesthesia and Pain Therapy of South Africa (RAPSA), Hands-on Animal Regional Anaesthesia Workshop, 2003.) In an epidural block, volumes and analgesic bupivacaine concentrations are usually within safe limits.

Fourthly, Sim and Webb demonstrated anatomical variations in the formation of the lumbar plexus in more than 40% of cadavers. Most of these variations were trivial, but in 12% an accessory obturator nerve was present. The accessory obturator nerve arises from the anterior divisions of the L3 and L4 nerve roots and does not lie in close approximation to the obturator nerve. They concluded that this anatomical variation can explain inadequate block during hip surgery.[16]

Finally, 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.[16] 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 the loss of resistance when reaching the epidural space. In the authors' opinion, exact needle tip position cannot be assumed clini-

cally, and injection of a local anaesthetic solution when aiming for the compartment may well be into the muscle itself. This concurs with the findings of Capdevila *et al*. They demonstrated radiologically that the catheter tip lies within the psoas major muscle in 74% of patients, and between the psoas and quadratus lumborum muscles (psoas compartment) in 22% of patients.[9] 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 the 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]

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 non-steroidal anti-inflammatory drugs should always be considered.[18]

Conclusion

Epidural analgesia was more effective than the psoas compartment block in providing analgesia 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 be considered in a patient with absolute or relative contraindications to epidural analgesia.

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