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Should We Use Hypobaric Bupivacaine in Spinal Anesthesia for ERAS Patients Undergoing Total Hip Arthroplasty

ERAS Protokolü ile Total Kalça Protezi Yapılan Hastalarda Hipobarik Bupivakain ile Spinal Anestezi Uygulamalı mıyız?

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ABSTRACT Objective: Enhanced Recovery After Surgery (ERAS) is a standardized perioperative care within a programme aims to reduce postoperative morbidity and length of hospital stay. The aim of this study was to evaluate which technique (hyperbaric or hypobaric spinal anesthesia) should we use in geriatric patients undergoing total hip arthroplasty according to ERAS. **Material and Methods:** 104 patients' records (52 of them hypobaric spinal, 52 of them had been applied hyperbaric spinal anesthesia), American Society of Anesthesiologists (ASA) I-III, undergoing total hip arthroplasty between June 2017-December 2017 was elected for study. Haemodynamic values, postoperative complications, hospital length of stay, readmission or reoperation after surgery, intensive care unit (ICU) length of stay, mortality, 30-day readmission two months' mortality rates, duration of surgery, gender, age, ASA and additional co-morbidities were recorded from the patients' files. **Results:** 38 males and 66 females were involved in the study, and their mean age was 76.24 years. The hospital length of stay, readmission or reoperation after surgery, ICU length of stay, duration of surgery were statistically significant differences between the groups. There were no statistically significant differences between the groups in 30-day readmission and mortality rates. When compared the blood pressures before and after the spinal block there were statistically significant differences between the groups. **Conclusion:** The aim of ERAS in the arthroplasty is to reduce the hospitalization time without increasing complications and readmission. We conclude that hypobaric solutions are suitable for ERAS protocol in total hip arthroplasty, but more studies should be done for evaluate effect of hypobaric spinal anesthesia related with ERAS protocol.

Keywords: ERAS; hypobaric; arthroplasty

ÖZET Amaç: Cerrahi Sonrası Hızlandırılmış İyileşme (ERAS), bir program dahilinde standart bir perioperatif bakım olup, postoperatif morbidite ve hastanede kalış süresini azaltmayı amaçlamaktadır. Bu çalışmanın amacı, ERAS'a göre total kalça artroplastisi uygulanan geriatrik hastalarda hangi tekniği (hiperbarik veya hipobarik spinal anestezi) kullanmamız gerektiğini değerlendirmektir. **Gereç ve Yöntemler:** Çalışmamıza Haziran 2017-Aralık 2017 tarihleri arasında total kalça artroplastisi uygulanan Amerikan Anesteziyoloji Derneği (ASA) I-III olan 104 hasta (52'sinde hipobarik spinal, 52'sinde hiperbarik spinal anestezi) kaydedildi. Hemodinamik değerler, postoperatif komplikasyonlar, hastanede kalış süresi, tekrar hastaneye yatış veya yeniden ameliyat olup olmadığı, yoğun bakım ünitesi (YBÜ) kalış süresi, mortalite, 30 gün içinde tekrar yatış, iki aylık mortalite oranları, ameliyat süresi, cinsiyet, yaş, ASA ve ek hastalıklar hastaların dosyalarından kaydedildi. **Bulgular:** Çalışmaya 38 erkek ve 66 kadın katıldı ve yaş ortalamaları 76,24 yıl idi. Ameliyat sonrası hastanede kalış süresi, tekrar hastaneye yatış veya yeniden ameliyat, YBÜ kalış süresi, ameliyat süresi gruplar arasında istatistiksel olarak anlamlı farklılık gösterdi. Gruplar arasında 30 gün içinde geri yatış ve mortalite oranları açısından istatistiksel olarak anlamlı fark yoktu. Spinal bloktan önce ve sonra kan basınçları karşılaştırıldığında gruplar arasında istatistiksel olarak anlamlı farklar vardı. **Sonuç:** Artroplastide ERAS'ın amacı komplikasyonları ve geri kabulleri arttırmadan hastanede yatış süresini azaltmaktır. Hipobarik spinal anestezinin total kalça artroplastisinde ERAS protokolü için uygun olduğunu ancak ERAS protokolüne bağlı kalarak hipobarik spinal anestezinin etkisini değerlendirmek için daha fazla çalışma yapılması gerektiğini düşünmekteyiz.

Anahtar Kelimeler: ERAS; hipobarik; artroplasti

Enhanced Recovery After Surgery (ERAS) is a standardized perioperative care within a programme aims to reduce postoperative morbidity and length of hospital stay (LOS). ERAS program has successfully showed advantage of the surgical patient in gastrointestinal and orthopaedic surgery. As well as reducing morbidity, enhanced recovery program in orthopaedic surgery has been demonstrated to reduce hospital length of stay, readmission rates or reoperation rates, admission rates to intensive care unit (ICU), 30-60 and 90-day mortality rates.[1]

Multimodal perioperative analgesia is preferred analgesic technique to control postoperative pain in ERAS protocols. In ERAS, low dose opioids or opioid free analgesia has been suggested to decrease opioid related adverse events, accelerate recovery and shorten length of stay.[2]

The most popular regional technique is spinal anaesthesia for geriatric patients undergoing total hip arthroplasty and hyperbaric local anesthetic (LA) preparations is commonly used. But, using of hyperbaric solutions may cause hypotension in 60–90% of geriatric patients during the perioperative period.[3-6] Total hip arthroplasty is usually conducted in the lateral decubitus position with the operated side up. As hypobaric solutions are less dense than cerebro spinal fluid, tend to ascend against gravity. Isobaric solutions are as dense as cerebro spinal fluid and hyperbaric solutions are denser than cerebro spinal fluid and tend to spread to lower part of spinal column after injection.

Because of the operated limb is on the nondependent part of patients' body during hypobaric spinal anaesthesia, hypobaric solutions tend to rise to the surface of cerebrospinal fluid and spread over to the most non-dependent regions of spinal column so, surgery can be done in the same position.[7-9] Showing that low dose hypobaric bupivacaine, administered via spinal route creates adequate surgical anesthesia and diminished the incidence of hypotension in elderly patients but duration could not be enough for procedures lasting longer than 80-90 min.[10] Sensory block duration can be prolonged adding low dose fentanyl to hypobaric local anaesthetic. Hypobaric 4 mL of 0.25 % bupivacaine (Plain 0.5%, bupivacaine 4 mL+distilled water 2.5 mL+1.5 mL fentanyl) solution or 0,5% hyperbaric bupivacaine 3 mL for spinal anaesthesia was used routinely in geriatric hip arthroplasty patients in our clinical practice. We use also this hypobaric spinal anesthesia technique as a part of ERAS protocol in our Clinic.

The aim of ERAS in the arthroplasty is to decrease the hospitalization time without escalating complications and readmission. In this present study, we reviewed LOS, readmission or reoperation after surgery, admission to ICU, LOS OF ICU, two months' mortality and 30-day readmission according to ERAS.

The objective of this study was to evaluate which technique (hyperbaric or hypobaric spinal anesthesia) should we use in geriatric patients undergoing total hip arthroplasty according to ERAS. We hypothesized that hip arthroplasty patients with hypobaric spinal anesthesia have faster recovery time compared to the ERAS protocol.

MATERIAL AND METHODS

A total of 108 patient documents were evaluated initially. Two patient files were excluded because of their ages were out of our age limits. Two of the other patients' documents were not filled out completely and were thus excluded. Finally, 104 patients were enrolled in this study retrospectively.

Total of 104 patients' records was evaluated from our database retrospectively in the study who had undergone total hip arthroplasty procedures between June 2017-December 2017. Total 52 of them had been applied hypobaric spinal anesthesia (10 mg isobaric bupivacaine+37.5mcg fentanyl+1.25cc distilled water) (hypobaric group), 52 of them had been applied hyperbaric spinal anesthesia (two mL of 5% hyperbaric bupivacaine-10 mg) (hyperbaric group). The records of the geriatric patients undergoing total hip art arthroplasty, between II-III ASA scores at the Department of Orthopaedics and Traumatology in our centre between June 2017 and December 2017 was elected for the study.

This study has been performed in accordance with the ethical standards set forth in Declaration of Helsinki.

Our inclusion criteria were; the patients who underwent total arthroplasty, over 65 years, ASA II-III and our exclusion criteria were; the patients who under 65 years.

After routine monitoring of the patients, the operated side was placed upwards and patient lay down on the lateral side. The lumbar area was cleaned with povidone iodine. When the most suitable intervertebral space (e.g. L3-4) was observed, a mixture of 4 mL (10 mg isobaric bupivacaine+37.5 mcg fentanyl+1.25 mL distilled water) was injected into the subarachnoid space with 25G quincke spinal needle. Haemodynamic values such as; blood pressures, heart rates, SpO_2 values before and after performing spinal anesthesia respectively, postoperative complications such as postoperative nausea and vomiting-post-spinal headache- urinary retention, hospital LOS, readmission or reoperation after surgery, ICU LOS, mortality and 30-day readmission two months' mortality rates, duration of surgery were recorded from the patients' files. The gender, age, ASA and additional co-morbidities were also documented from the files retrospectively.

We recorded patients' data: intraoperative hemodynamic consequences, postoperative complications such as postoperative nausea and vomiting-post-spinal headache- urinary retention, hospital LOS, readmission or reoperation after surgery, admission to ICU, ICU LOS, mortality and 30-day readmission according to ERAS protocol.

Because of LOS, readmission or reoperation after surgery, admission to ICU, mortality and 30-day readmission are the most important predictors in ERAS protocol, the primary result of this retrospective analysis was hospital and ICU LOS. Secondary results included, 30-day readmission rates, readmission or reoperation after surgery, length of and admission to ICU and mortality in two months period.

This study was certified by the local ethics committee with date and number of 2017.1.10.

STATISTICAL ANALYSES

The SPSS statistical package, version 15.0 (SPSS Inc, Chicago, IL, USA) was used to analyse the statistics. Data were checked for a normal distribution using the SPSS® statistical package. Non-parametric tests (Mann-Whitney U-test and x^2-test) were used for data that were not normally distributed. A p-value <0.05 was considered statistically significant.

RESULTS

38 males and 66 females were involved in the study, and their mean age was 76.24 years (hypobaric group 76.96 years, hyperbaric group 75.51 years). The demographic data of the patients are presented in (Table 1).

According to ERAS protocol, we reviewed hospital LOS, readmission or reoperation after surgery, admission to ICU, ICU LOS, mortality and 30-day readmission. There were no statistically significant differences between the groups in 30-day readmission (p >0.05). But when compared the hospital LOS, readmission or reoperation after surgery, admission to ICU, ICU LOS there were statistically significant differences between the groups (p <0.05). However, when long-term mortality was investigated, 10 patients in the hyperbaric group and 3 patients in the hypobaric group died. It was clinical differences between groups but not in statistically (Table 2).

One patient in the hyperbaric group had nausea, and urinary retention and 1 patient had vomiting in postoperative period. None of our patients had post-spinal headache or lumbar pain (Table 3).

There were no statistically significant differences between the groups in blood pressures and heart rates (p >0.05). But when compared the blood pressures before and after the spinal block there were statistically significant differences between the groups (p <0.05) (Table 4, Table 5).

TABLE 1: Demographic characters of the patients.

Age (mean) (year)	76.24 years
ASA (II/III)	55/99
Sex (F/M)	66/38

TABLE 2: Comparison of hospital LOS, readmission or reoperation after surgery, admission to ICU, ICU LOS, mortality and 30-day readmission between groups.

	Hypobaric (n=52)	Hyperbaric (n=52)	P*
LOS (day)	42.80 (median)	62.20 (median)	0.01*
Reoperation	11.5% (6)	30.2% (16)	0.016*
ICU admission and LOS	46.58 (median)	58.42 (median)	0.022*
Mortality	5.8% (3)	19.2% (10)	0.075
30-day readmission	7.7% (4)	21.2 % (11)	0.01

LOS: Length of hospital stay, ICU: Intensive care unit.

TABLE 3: Adverse effects in the patients.

	Hypobaric (n=52)	Hyperbaric (n=52)
Bradycardia	1	2
Nausea and vomiting	0	1
Urinary retention	0	1
Headache	0	0
Lumbar pain	0	0

There were no significantly differences between groups related with two months of mortality rates. One patient died in hypobaric group and two patients died in hyperbaric group ($p>0.05$). However, when long-term mortality was investigated, 10 patients in the hyperbaric group and 3 patients in the hypobaric group died. It was clinical differences between groups but not in statistically.

In hypobaric group, higher patient comfort due to the spinal anesthesia had been performed in the same side (operated side was in the upward) as the surgical position. There were statistically significant differences between two groups according to duration of surgery ($p <0.05$).

DISCUSSION

Total hip arthroplasty (THA) is frequently performed under spinal anesthesia; using either hyperbaric, isobaric and hypobaric local anesthetic solution. Hypobaric technique is an old fashioned one, however, hypobaric spinal anesthesia for THA have potential advantages related with body position and provides less dense block than hyperbaric technique although bupivacaine is one of the longest acting patent local anesthetic agent.

TABLE 4: Comparison of blood pressures before and after the spinal block.

	Hypobaric (n=52)	Hyperbaric (n=52)	p
Blood pressures before block	100.5 (63-173)	109.5 (66-153)	0.075
Blood pressures after block	96.0 (70-150)	88.0 (52-123)	0.066
Heart rates before block	81.5 (60-138)	85.0 (59-160)	0.927
Heart rates after block	82.5 (55-120)	85.0 (45-140)	0.837
SpO2 before block	95.5 (77-100)	99.0 (62-100)	0.003*
SpO2 after block	97.5 (86-100)	100 (72-100)	<0.001*
Operation time (minute)	72.5 (35-180)	90.0 (35-180)	0.507

*p <0.05 significantly different.

TABLE 5: Comparison of blood pressure differences before and after the spinal block.

	Hypobaric (n=52)	Hyperbaric (n=52)	Hypobaric p	Hyperbaric p
Heart rates (differences)	-0.5 (-28-15)	-2.0 (-42-25)	0.059	0.917
Blood pressures (differences)	4.0 (-20-63)	18.0 (-17-64)	<0.001*	<0.001*

*p <0.05 statistically significant.

LOS

The most important clinical pathway and predictor for ERAS involving THA is hospital length of stay (LOS). Auyong et al. showed that association of last discoveries in the perioperative care of arthroplasties can result in clinically revealing reduces in postoperative length of stay without rising readmission rates.[11] Length of stay reduced after implementation of the evidence-based orthopaedic enhanced recovery after surgery pathway compared with the LOS of the non-ERAS group, the LOS of the ERAS groups had different degrees of reductions in the arthroplasty. Khan et al. retrospectively analysed arthroplasty patients under ERAS protocol.[12] Like our study, they found that ERAS protocol significantly shortened LOS. In a meta-analysis showed that the application of ERAS can significantly reduce LOS and incidence of complications in patients who have had THA. In this present study, LOS is significantly lower in our hypobaric ERAS group and our results seems to be same as the other researches.[2]

REOPERATION OR READMISSION

Khan et al. also analysed that ERAS reduced reoperation rate and readmission to hospital compared with traditional knee arthroplasty.[12] Auyong et al. collected data on 252 primary total knee arthroplasties analysed re-admission rates in that meta-analysis according to ERAS pathway, they found that ERAS protocol significantly reduces the reoperation and readmission rates.[11] In our study we also found that patients in hypobaric group reoperation rates were statistically significant lower than the hyperbaric group and this result was in accordance with the literature.

30-DAY READMISSION

However, in a systematic review and meta-analysis in ERAS for hip and knee arthroplasty, Zhu et al. analysed that ERAS does not appear to significantly impact on 30-day readmission rates.[2] Their meta-analysis included in the system showed that the application of ERAS can reduce length of hospitalization but not increase 30-day readmission rate like our study. Also Auyong et al. and Khan et al. showed that difference in 30-day readmission rates was not statistically significant between ERAS and non-ERAS groups.[11,12] As their findings meta-analyses, we also did not find any statistically significant differences between hypobaric (ERAS group) and hyperbaric groups.

READMISSION TO ICU AND ICU LOS

As our knowledge of the ERAS pathway has known, increasing reliability and effectiveness of recovery for patients undergoing orthopaedic arthroplasty has also grown. Admission to ICU is a part of this subject for postoperative and recovery period. A known fact that admission to ICU and long ICU stay days showed unsuccessful recovery. In our study, there is significantly differences between two groups that in hypobaric group ICU LOS is statistically significant lower. We have not been able to find any study on this issue and for that our literature is worthwhile study.

MORTALITY

Mortality is the other important part of the ERAS. Liu et al. showed in their meta-analyses hospital mortality rate was lower in ERAS group but they did not find any results about long term mortality.[13] In many meta-analyses to decreasing morbidity, ERAS programmes in orthopaedics have been shown to reduce 30- and 90-day mortality rates.[14,15] However, in our study, there were no significantly differences between two groups related with two months of mortality rates and when long-term mortality was investigated, 10 patients in the hyperbaric group and 3 patients in the hypobaric group died. It was clinical differences between groups but not in statistically.

CONCENTRATION AND BARICITY

The major determinants of spread of intrathecally administered solutions are their dose, volume, concentration and baricity. The dose, volume and concentration of an anaesthetic agent are inter-related as the dose is a product of the volume and concentration. Because acute cardiovascular event is one of the frequent intraoperative problem due to usage of hyperbaric solutions, so anesthesiologist should

be more cautious in these type of patients.[10] Hypobaric spinal anesthesia produces well conditions while minimizing hemodynamic change in the elderly population.[1] The reduction of local anesthetic dose (adding adjuvants like opioids) and sympathectomy can contribute to more favourable haemodynamics and theoretically better outcomes in the elderly population.[16,17] We prefer to use hypobaric spinal anesthesia, due to difficulties of changing patient positions, advantage of decrease in urinary retention and better patient and surgeon satisfaction. During hypobaric spinal anesthesia, hypotension incidence is reduced, and recovery period shortened in our study.

Baricity is defined as ratio of density of local anesthetic solution to density of cerebrospinal fluid efficacy. Solutions that have the same density as cerebrospinal fluid have a baricity of 1 and are called isobaric. Solutions that are denser than cerebrospinal fluid are named hyperbaric, whereas solutions that are less dense are named hypobaric.[18]

The effects of baricity of local anesthetic solution on onset, duration, and spinal anesthesia have been evaluated in many studies. Kim et al. performed a study to detect the anesthetic profiles and dose-response of hypobaric tetracaine, as a single-shot spinal anesthetic for THA.[7] They added ten mL of sterile water to 20 mg of tetracaine to make a 0.2% hypobaric solution and they established spinal anesthesia and dose effects of 10, 12, or 14 mg tetracaine that 5, 6 or 7 mL of this solution. They evaluated different doses of hypobaric solution and found hypobaric local anesthetic solutions due to more comfortable spinal anesthesia both surgeon and anesthesiologist. In our study a mixture of 10 mg isobaric bupivacaine +37.5mcg fentanyl +1.25 ml distilled water and 10 mg hyperbaric bupivacaine ensured well levels of anesthesia during total hip arthroplasty and recovery of anesthesia and spinal anesthesia characteristics were more better than hyperbaric spinal anesthesia.

HAEMODYNAMICS

In different surgeries, different baricities of the local anesthetics for the spinal anesthesia were used. In one study, Vernhiet et al. recommended that use of hyperbaric for spinal anesthesia is associated with fewer unsuccess incidence compared to isobaric, but, similarly to our study there was lower incidence of hypotension with isobaric.[19] Some studies have showed that the ratio of hypotension is higher with use of hyperbaric for spinal anesthesia.[20] In our study, hypotension after spinal block than before spinal block was significantly higher in the hyperbaric group. Conversely, others have showed similar ratio of hypotension or a lower incidence of hypotension with using hyperbaric.[21,22]

Casati et al. said that the use of local anesthetic solution in different concentrations affects the outcome of unilateral spinal block.[23] In addition Faust et al. found that for THA in the lateral position with hypobaric block seems to superior isobaric, it prolongs the sensory block on the operative side without compromised hemodynamic stability.[24] In our study, all spinal blocks were performed successfully. The patients had no pain or complications during or after surgery. Additionally, operation times were shorter in hypobaric group because of the position were the same both when performing spinal anesthesia and surgery. This is related to both the rapid onset of analgesia and uncontrolled upper plane of anesthesia.[25] Because of patients did not need lay on the operated limb or hip for performing block hypobaric spinal anesthesia is especially useful for hip or lower extremity fractures or arthroplasties. This may be the reason why anesthesiologists use and trust preferably in hyperbaric solutions.[26] In this present study the position was operative side up in the hypobaric group.

Hypobaric spinal anesthesia was used in different surgery types. Quan et al. used that in Caesarean Section and suggested that Combined use of hyperbaric and hypobaric ropivacaine significantly reduced the rates of hypotension and complications in spinal anesthesia for caesarean section.[25] Faust et al[24] compared the anesthetic and hemodynamic effects of isobaric and hypobaric bupivacaine solutions for THA performed with patients in the lateral decubitus position. It was the same position with our study and they used isobaric bupivacaine

versus hyperbaric one. Similar to our study they found no difference in quality of motor block was noted during or after the surgery. They concluded that for THA in the lateral position, spinal hypobaric bupivacaine seems to be superior to isobaric.

SIDE EFFECTS

The incidence of side effects such as hypotension, bradycardia, nausea and vomiting may be changed by spread of local anesthetic of nerve roots/segments blocked in the spinal cord. In this present study, only one patient in the hyperbaric group had nausea, and urinary retention and 1 patient had vomiting in postoperative period. There were no nausea and vomiting or urinary retention seen in hypobaric group. Existing of nausea, vomiting and urinary retention can negatively effect ERAS protocol. According to our results, hypobaric spinal anesthesia technique did not have any negative effect on ERAS because none of our patients had any side effects.

CONCLUSIONS

As a result, enhanced recovery after surgery (ERAS) pathway is the most popular subject that about decreasing hospital length of stay (LOS). Unilateral spinal anesthesia with hypobaric bupivacaine provided a good hemodynamic stability and it helps ERAS. Hypobaric spinal is indeed a good choice for total hip arthroplasty surgeries. It produces reliable sensory as well as motor blockade with excellent hemodynamic stability and postoperative analgesia. It is more comfortable to the patient and surgeon compared to hyperbaric spinal in ERAS pathway. We conclude that hypobaric solutions are suitable for ERAS protocol in THA, but more studies should be done for evaluate effect of hypobaric spinal anesthesia related with ERAS protocol.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Abdurrahim Derbent, Ayça Sultan Şahin;* ***Design:*** *Ayça Sultan Sahin, Abdurrahim Derbent;* ***Supervision/Consultancy:*** *Abdurrahim Derbent, Ayça Sultan Şahin;* ***Data Collection and/or Processing:*** *Necmiye Ay, Ayça Sultan Şahin;* ***Analysis and/or Interpretation:*** *Ayça Sultan Sahin, Abdurrahim Derbent;* ***Source Browsing:*** *Ece Salihoğlu, Ayça Sultan Şahin;* ***Written by Makalen:*** *Ayça Sultan Şahin;* ***Critical Review:*** *Abdurrahim Derbent;* ***Resources and Funding:*** *Necmiye Ay;* ***Materials:*** *Necmiye Ay;* ***Statistics:*** *Ece Salihoğlu, Baris Sandal.*

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