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Спинальная анестезия с применением прилокаина и бупивакаина в урологической эндоскопии: клинические испытания и исторический обзор

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РЕЗЮМЕ

Введение. В условиях меняющегося подхода к анестезиологической практике кратковременных урологических вмешательств поиск анестетика, сочетающего эффективность с минимальным количеством побочных эффектов, остается важной клинической задачей.

Цель – сравнить эффективность и безопасность 2% гипербарического прилокаина и 0,5% гипербарического бупивакаина при спинальной анестезии.

Материалы и методы. Сравнительный анализ проведен с точки зрения возникновения и продолжительности сенсорной и моторной блокады, частоты побочных эффектов (артериальная гипотензия и брадикардия) и общих результатов лечения пациентов, перенесших урологические эндоскопические вмешательства. Исследовательская выборка была разделена на 2 группы, каждая из которых состояла из 20 пациентов. В одном случае спинальную анестезию проводили с использованием 2% гипербарического раствора прилокаина (40 мг) + фентанил 25 мкг, в другом – 0,5% раствором гипербарического бупивакаина (10 мг) + фентанил 25 мкг.

Результаты. Прилокаин обеспечивал более быстрое наступление сенсорной и моторной блокады при меньшей продолжительности сенсорной блокады по сравнению с бупивакаином. Применение прилокаина также сопровождалось более быстрым восстановлением двигательной функции и значительно меньшей частотой побочных эффектов, таких как артериальная гипотензия и брадикардия.

Заключение. Полученные результаты позволяют предположить, что 2% гипербарический раствор прилокаина может быть альтернативой 0,5% гипербарическому раствору бупивакаина при спинальной анестезии при урологической эндоскопии, особенно при процедурах, требующих быстрого восстановления. Хорошие результаты применения прилокаина при подобных кратковременных операциях также могут способствовать изменению алгоритмов применения анестетиков при других хирургических вмешательствах и улучшению результатов лечения пациентов, повышая безопасность, комфорт и эффективность хирургического лечения.

Ключевые слова: спинномозговая анестезия, урологическая эндоскопия, прилокаин, бупивакаин, эффективность анестезии

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Prilocaine vs bupivacaine in spinal anesthesia for urologic endoscopy: clinical trials & historical overview

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ABSTRACT

Introduction. In the evolving landscape of anesthetic practices for short-duration urologic procedures, the quest for an anesthetic agent that balances efficacy with minimal side effects remains a significant clinical challenge.

The **objective** was to compare the efficacy and safety of 2% hyperbaric prilocaine and 0.5% hyperbaric bupivacaine in spinal anesthesia.

Materials and methods. A comparative analysis was performed in terms of onset and duration of sensory and motor block, incidence of side effects (hypotension and bradycardia), and overall patient outcomes in urologic endoscopy. The research sample was divided into two groups, each consisting of 20 patients. In one case, spinal anesthesia was performed using 2% hyperbaric prilocaine (40 mg) + fentanyl 25 mcg, in the other – 0.5% hyperbaric bupivacaine (10 mg) + fentanyl 25 mcg.

Results. Prilocaine offers a faster onset of sensory and motor block and a shorter duration of sensory block compared to bupivacaine. Prilocaine also showed a quicker recovery of full motor function and had a significantly lower incidence of side effects such as hypotension and bradycardia.

Conclusion. These results suggest that 2% hyperbaric prilocaine could be an alternative to 0.5% hyperbaric bupivacaine in spinal anesthesia for urologic endoscopy, especially in procedures requiring quick recovery. The promising results of prilocaine in such short-duration surgeries can also prompt a reevaluation of anesthesia protocols across various surgical interventions and lead to enhanced patient outcomes, emphasizing safety, comfort, and efficacy of surgical care.

Key words: spinal anesthesia, urologic endoscopy, prilocaine, bupivacaine, anesthetic efficacy

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Introduction

In the field of modern medical practice, urological endoscopy is pivotal for the diagnosis and treatment of various urological conditions, offering a minimally invasive alternative to conventional surgery. This method significantly reduces recovery times and complications, underscoring its critical role in contemporary medicine [9, 11, 17, 27]. Diagnostic urological endoscopy, performed as an outpatient surgical procedure, emphasizes

the importance of anesthesia techniques that allow for rapid patient discharge. Local anesthesia is commonly used despite its unpredictability and potential discomfort for patients. Selective spinal anesthesia with short-acting hyperbaric local anesthetic agents offers a solution by ensuring rapid sensory and motor block, predictable duration, and low side-effect incidence. Spinal anesthesia is highly reliable, providing effective analgesia with minimal side effects, quick turnover time, and low cost, making it highly suitable for urological endoscopy procedures [7, 8]. The efficacy of these procedures, especially in outpatient settings, hinges significantly on the anesthesia employed. A pivotal transition, as Munro & Uppal [19] elucidate, has been from traditional local anesthesia to advanced techniques like selective spinal anesthesia using short-duration hyperbaric local anesthetics. This advancement is notable for its combination of reliability, effective pain relief, minimal side effects, and cost-effectiveness, making it increasingly preferred in urological endoscopy due to its profound influence on patient recovery and procedural efficiency.

Dating back to 1885, spinal anesthesia has undergone substantial developments, now encompassing surgeries of the lower abdomen, perineum, and lower extremities. T. Yaksh & S. Hayek [28] provide a comprehensive historical overview of spinal anesthesia's evolution, noting its application through both epidural and spinal routes. The administration of local anesthetics into the subarachnoid space for targeted analgesia at specific dermatome levels is a key aspect of this technique. The selection of appropriate candidates for spinal anesthesia necessitates an in-depth understanding of patient-specific conditions and the dynamics of anesthetic agents [16].

In urological endoscopy, the precise application of spinal anesthesia is vital for effective pain management and minimizing physiological stress on patients. B. H. Li et al. [18] emphasize the significance of patient stability and comfort in minimally invasive urological techniques, underscoring the necessity for carefully tailored anesthesia strategies.

The use of traditional anesthetics like lidocaine and bupivacaine faces challenges in clinical practice. Lidocaine's link to transient neurological symptoms following intrathecal administration has led to reduced usage. Conversely, while bupivacaine is less associated with transient neurological symptoms (TNS), it carries risks of cardiotoxicity and postoperative urinary retention. These challenges underscore the need to explore safer, more effective anesthetic alternatives in urological procedures [23].

The FDA's 2020 endorsement of prilocaine for short-duration spinal anesthesia signifies a major advancement. Known for its rapid onset and moderate potency, prilocaine, a member of the amino-amide local anesthetics class, offers several advantages, including lower systemic toxicity and hemodynamic disturbances. Its usage, however, demands careful dosage adjustments, as R. S. Cismasiu et al. highlight in their study on optimizing anesthesia management across various surgical contexts [6].

Recent research has focused on comparing hyperbaric bupivacaine and prilocaine in outpatient surgeries. C. H. Koo et al. [15]; P. Radkowski et al. [20] delve into the neurological implications of general anesthesia, providing relevant insights into the effects of different anesthetic agents in varied surgical settings.

Despite prilocaine's growing preference, a research gap persists in its application in urological endoscopy, particularly beyond TURB procedures. This study seeks to bridge this gap by comparing the efficacy of 2% hyperbaric prilocaine and 0.5% hyperbaric bupivacaine in such surgeries. Our research is poised to significantly impact the scientific community and medical practitioners, enriching the knowledge base on spinal anesthetics and influencing future anesthesia policies and guidelines in urological endoscopy.

Materials and Method

This study employed a comprehensive randomized controlled trial design, meticulously focusing on patients scheduled for short-duration urologic endoscopy. The participant selection was guided by stringent inclusion and exclusion criteria, tailored to the specific requirements of urologic endoscopic procedures. Upon obtaining ethical clearance from the institutional review board and ensuring informed consent from all participants, subjects were methodically assigned to either the 2% hyperbaric prilocaine group or the 0.5% hyperbaric bupivacaine group for spinal anesthesia. Participant selection was meticulously strategized using a stratified random sampling approach. This method ensured a representative cross-section of the patient population undergoing short-duration urologic endoscopy. Criteria for inclusion were carefully delineated, encompassing age, health status, and specific medical histories pertinent to the anesthesia types under study. Exclusion criteria were equally rigorous, excluding patients with contraindications to either anesthetic or those with complicating medical conditions. This judicious selection process, combined with stratified sampling, ensured a robust and representative sample, crucial for the validity and generalizability of our findings.

Research Population and Sample. The sample used in this study comprised patients who underwent urology endoscopy procedures with spinal anesthesia at Wahidin Sudirohusodo Makassar Central General Hospital (RSUP), who met the inclusion criteria, and agreed to participate in the research, selected using consecutive sampling method. This research was conducted on 40 patients undergoing urological endoscopy procedures with spinal anesthesia at Dr. Wahidin Sudirohusodo Hospital in Makassar. The research sample was divided into two groups, each consisting of 20 patients, including a group using spinal anesthesia with 2% hyperbaric prilocaine 40 mg + fentanyl 25 mcg and a group using spinal anesthesia with 0.5% hyperbaric bupivacaine 10 mg + fentanyl 25 mcg.

The minimum sample size estimated could be calculated using the formula for the analysis of the mean comparison of two sample groups as follows:

$$n = \frac{2(Z_{1-\frac{\alpha}{2}} + Z_{\beta})^2 \sigma^2}{(U_1 - U_2)^2}.$$

Explanation:

n = Minimum sample size per group;

Z_{α} = Type I error, set at 5% with a two-tailed hypothesis (1.96);

Z_{β} = Type II error set at 10% (1.28);

U_2 = Onset of sensory block in the prilocaine group = 6.78;

U_1 = Onset of sensory block in the bupivacaine group = 138;

σ = estimated standard deviation = 6 Thus, the value of n in this study is:

$n = (2 \cdot (1.96+1.28)^2 (6)^2)/(13–6.7)^2 = 19.04$ (rounded to 20)

Based on the formula above, the minimum sample size per group was 20.

Inclusion and Exclusion Criteria. The *inclusion criteria*:

– Patients who underwent urology endoscopy procedures with spinal anesthesia;

– Aged 18–60 years;

– ASA physical status I–II;

– Height 155–175 cm (Homogeneous sampling to avoid biases);

– Body Mass Index (BMI) 18.5 – 24.9 kg/m^2;

– Agreed to participate in the research.

Exclusion criteria:

– Patients who underwent transurethral resection of the prostate (TURP) and transurethral resection of bladder tumor (TURBT);

– Patients with absolute contraindications to spinal anesthesia;

– Patients with hypersensitivity to local amide anesthesia;

– Pregnant patients;

– Patients with psychiatric diseases;

– Patients who refused to participate in the research.

The dropout criteria in this study were:

– Procedure duration > 90 minutes;

– Patients experiencing complications during the study;

– Patients withdrawing from the research.

Dropout management was an integral component, designed to address and mitigate participant withdrawal or loss to follow-up. Strategies to minimize dropout rates involved regular follow-up communications, flexible scheduling for assessments, and ensuring participant comfort and understanding of the study processes. In cases of dropout, a thorough review was conducted to understand the underlying reasons, and appropriate statistical methods were applied to handle the missing data, thus preserving the study's integrity and the validity of its conclusions.

Research Permission and Ethical Fitness. Before the research is conducted, the researcher requests ethical clearance from the Biomedical Research Ethics Commission on humans at the Faculty of Medicine, Hasanuddin University, and the Education and Research Department of RSUP Dr. Wahidin Sudirohusodo Makassar. All patients meeting the inclusion criteria are given an oral explanation and sign a consent form to voluntarily participate in the research. The study rigorously adhered to the principles of the Helsinki Declaration, emphasizing patient safety, confidentiality, and the right to withdrawal. Continuous monitoring and audits ensured adherence to these ethical standards.

Data Analysis. Data collection was designed to be comprehensive and precise, encompassing not only the onset and duration of both sensory and motor blocks but also meticulously documenting any occurrences of side effects such as hypotension and bradycardia. Patient outcomes, including recovery times and subjective experiences, were systematically recorded, providing a holistic view of the procedural efficacy and safety. The data analysis was grounded in robust statistical methods tailored for comparative clinical studies.

The collected data was tabulated into Excel and then analyzed using SPSS 23 for Windows. Univariate analysis was performed by calculating the count, percentage, mean, median, and standard deviation of the research variables and patient characteristics. Bivariate tests were conducted to examine differences between two groups with numeric data distributions using the independent sample T-Test when the data was normally distributed, and the Mann–Whitney U-Test for non-normally distributed data. Changes in numeric variables over time were analyzed with the paired T-Test for normally distributed data, and the Wilcoxon Z-Test for non-normally distributed data. Normality of data was tested using the Shapiro–Wilk Test. To examine differences among variables with all categorical data, the Chi-Square Test was used (if no expected count value < 5), but if any cell had an expected count value < 5, then the Fisher's Exact Test was applied.

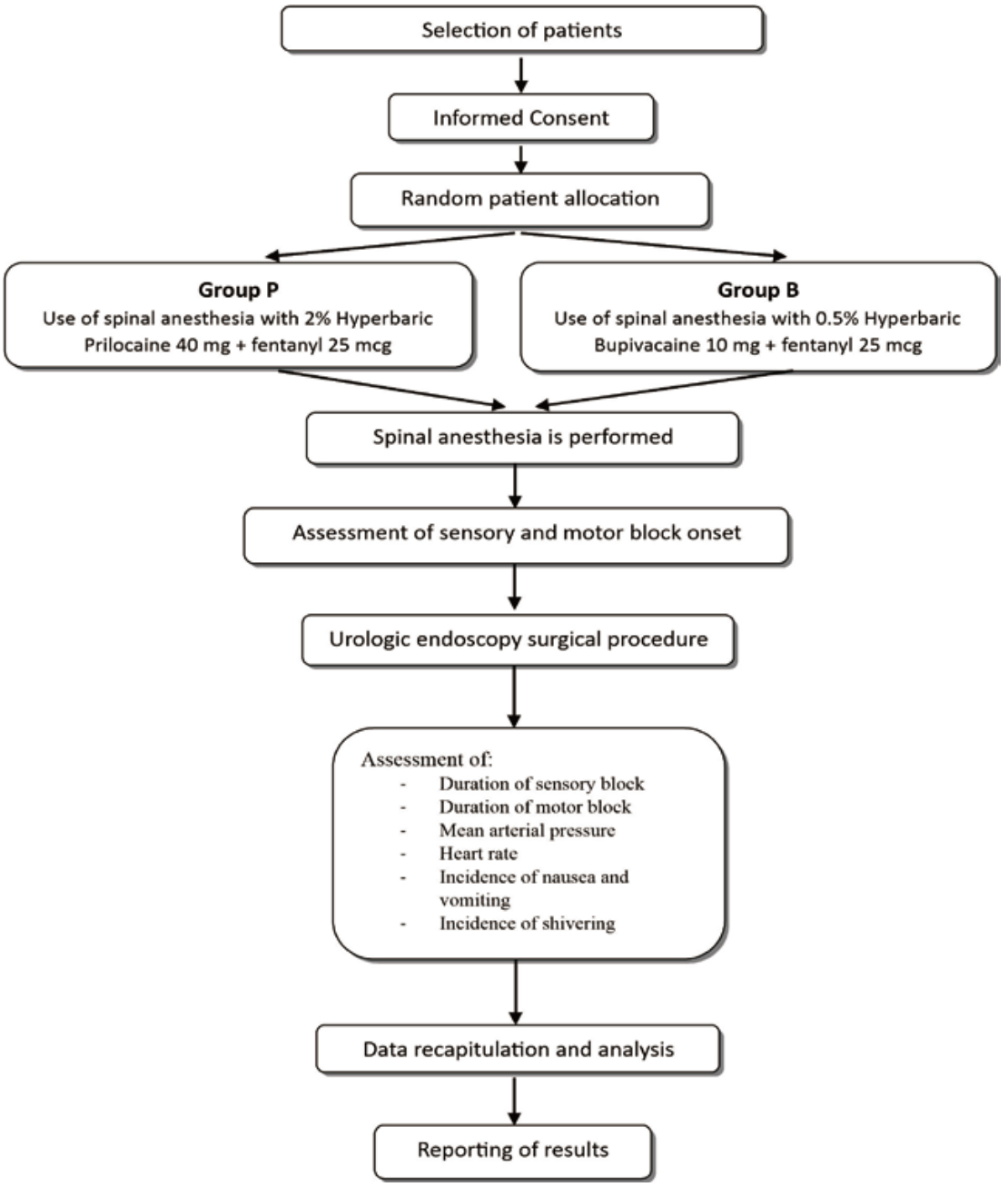
Framework. To succinctly illustrate the methodological framework of our study, a detailed flowchart delineating the entire process – from patient selection and randomization to anesthesia administration, data collection, and analysis – was developed. Furthermore, a comprehensive table was included to outline the statistical methods utilized, providing clarity and transparency to our analytical approach.

Results

The characteristics of the study sample for both groups are presented in the table 1.

According to the table 1, the age group, gender, body mass index, and physical status were tested between the prilocaine and bupivacaine groups with results $p > 0.05$, indicating both groups have homogeneous data suitable for comparison.

Comparison of Sensory Block Onset and Motor Block Onset. The comparison between sensory block onset



Framework of the Research

Table 1. **Sample characteristics based on age, gender, body mass index, and physical status**

Characteristic		Prilocaine (Median (Min–Max))	Bupivacaine (Median (Min–Max))	P Value
Age (years)		39 (24–56)	46 (18–58)	0.265^{ns}
Gender	Male (%)	13 (52)	9 (48)	0.204^{ns}
	Female (%)	7 (38.8)	11 (61.2)	
Body Mass Index (kg/m^2)		22.9 (18.5–26.0)	23.4 (19.4–25.0)	0.495^{ns}
Physical Status (ASA PS)		2 (1–2)	2(2–2)	0.602^{ns}

N o t e: Gender data processed using Chi-Square Test, other variables using Mann–Whitney U-Test, ^{ns} – not significant (homogeneous data).

and motor block onset in the prilocaine and bupivacaine groups is shown in the table 2.

The table 2 indicates significant differences in the sensory block onset between prilocaine and bupivacaine groups, with prilocaine showing a faster onset with a *p*-value of 0.007. For motor block onset, prilocaine is faster with a median of 3 minutes compared to 4 minutes for bupivacaine, which is statistically significant as the *p*-value is < 0.05.

The comparison of sensory and motor block duration between the Prilocaine and Bupivacaine groups is presented in the table 3.

***Table 2*. Sensory and motor block onset in prilocaine and bupivacaine groups**

Onset	Prilocaine (Median (Min–Max))	Bupivacaine (Median (Min–Max))	P Value
Sensory Block (Minutes)	3.0 (2.0–4.0)	3.0 (3.0–4.0)	0.007*
Motor Block (Minutes)	3.0 (2.0–5.0)	4.0 (4.0–6.0)	< 0.001*

N o t e: Data tested with Mann–Whitney U-Test, * – significant.

***Table 3*. Duration of sensory and motor blocks in both groups**

Duration	Prilocaine (Median (Min–Max))	Bupivacaine (Median (Min–Max))	P Value
Sensory Block (Minutes)	91.0 (83.0–104.0)	188.5 (183.0–197.0)	< 0.001*
Motor Block (Minutes)	102.0 (92.0–117.0)	220.0 (203.0–227.0)	< 0.001*

N o t e: Data tested with Mann–Whitney U-Test, * – significant.

***Table 4*. Comparison of mean arterial pressure between the prilocaine group and the bupivacaine group**

Measurement Time	Prilocaine	Bupivacaine	P value
	Mean ± SD	Mean ± SD	
T0	94,98 ± 5,39	97,03 ± 6,76	0,314 ns
T1	91,46 ± 5,13	85,41 ± 7,01	0,013*
T2	90,31 ± 5,46	85,58 ± 5,22	0,030*
T3	88,61 ± 4,56	90,98 ± 5,46	0,134ns
T4	89,55 ± 4,63	92,51 ± 5,61	0,102ns
T5	94,76 ± 5,89	91,85 ± 3,86	0,060ns
T6	93,86 ± 5,22	92,28 ± 5,58	0,529ns
T7	91,68 ± 5,55	94,51 ± 4,67	0,183 ns
T8	92,63 ± 4,43	93,68 ± 4,41	0,883 ns
T9	92,50 ± 5,21	92,80 ± 4,01	0,495ns
T10	93,58 ± 4,78	92,15 ± 3,41	0,779 ns
T11	94,73 ± 5,09	92,96 ± 4,36	0,242 ns
T12	91,66 ± 4,80	89,55 ± 4,65	0,183 ns
T13	89,88 ± 5,07	88,55 ± 4,86	0,461 ns
T14	91,23 ± 5,65	89,33 ± 5,68	0,221 ns
T15	92,65 ± 5,79	90,80 ± 4,77	0,277 ns
T16	94,11 ± 6,15	92,55 ± 5,07	0,659 ns
T17	94,58 ± 5,44	91,61 ± 4,58	0,134 ns
T18	94,35 ± 4,25	92,30 ± 4,97	0,989 ns
T19	93,65 ± 4,41	92,38 ± 4,29	0,904 ns
T20	92,81 ± 4,81	92,36 ± 3,98	0,841 ns
T21	93,10 ± 5,12	91,35 ± 2,97	0,445 ns
T22	91,61 ± 5,16	88,25 ± 4,31	0,063 ns
T23	92,51 ± 4,95	90,20 ± 5,17	0,174 ns
T24	93,20 ± 4,74	93,96 ± 5,24	0,718ns

N o t e: Data displayed with mean ± standard deviation. Mann–Whitney Test. * – significant; ns: not significant.

The table 3 shows significant differences in the duration of motor and sensory blocks between prilocaine and bupivacaine groups, with prilocaine showing shorter durations ($p < 0.05$).

Comparison of Hemodynamic Responses. The comparison of mean arterial pressure between the prilocaine and bupivacaine groups can be seen in the table 4.

The table 4 shows that there is a significant difference in mean arterial pressure (MAP) at T1 and T2 between the prilocaine group and the bupivacaine group. It reveals that the mean arterial pressure in the prilocaine group is higher compared to the bupivacaine group. It is observed that in the bupivacaine group at T1 and T2, there is a significant decrease in mean arterial pressure.

Comparison of Pulse Rate. The comparison of pulse rates between the prilocaine and bupivacaine groups can be seen in the table 5.

The table 5 shows that there is a significant difference in pulse rate at T1, T2, T10, T11, T12, T13, T15, T17, T19, and T20 between the prilocaine group and the bupivacaine group. It reveals that the pulse rate in the prilocaine group appears more stable compared to the bupivacaine group. There is a steep increase in pulse rate at T1 and T2 in the bupivacaine group.

Table 5. **Comparison of pulse rate between the prilocaine group and the bupivacaine group**

Time Measurement	Prilocaine	Bupivacaine	P value
	Mean ± SD	Mean ± SD	
T0	77,30 ± 4,35	81,35 ± 8,88	0,091^{ns}
T1	78,40 ± 6,54	90,85 ± 10,78	0,001*
T2	78,80 ± 4,78	88,35 ± 7,12	0,001*
T3	79,90 ± 5,47	83,35 ± 6,80	0,108^{ns}
T4	79,75 ± 5,48	82,00 ± 6,98	0,127^{ns}
T5	79,90 ± 3,85	81,90 ± 5,85	0,072^{ns}
T6	79,25 ± 4,11	82,10 ± 7,15	0,081^{ns}
T7	77,75 ± 4,06	81,20 ± 7,11	0,096^{ns}
T8	78,35 ± 3,32	80,60 ± 6,96	0,277^{ns}
T9	77,85 ± 4,13	81,50 ± 6,34	0,091^{ns}
T10	78,50 ± 3,60	82,50 ± 5,67	0,024*
T11	77,70 ± 5,33	83,90 ± 7,07	0,007*
T12	78,30 ± 6,13	83,85 ± 7,55	0,024*
T13	79,20 ± 5,12	83,95 ± 6,99	0,020*
T14	79,65 ± 5,77	81,60 ± 7,98	0,429^{ns}
T15	79,65 ± 4,76	82,50 ± 6,49	0,040*
T16	80,05 ± 3,96	82,55 ± 6,27	0,060^{ns}
T17	78,85 ± 4,24	82,00 ± 6,00	0,040*
T18	77,50 ± 3,79	79,95 ± 7,07	0,341^{ns}
T19	78,60 ± 3,73	82,45 ± 6,54	0,015*
T20	77,90 ± 3,53	82,20 ± 5,86	0,024*
T21	78,85 ± 4,14	81,25 ± 5,77	0,149^{ns}
T22	77,90 ± 4,98	81,40 ± 7,09	0,102^{ns}
T23	79,90 ± 5,11	81,85 ± 7,16	0,183^{ns}
T24	79,95 ± 4,78	82,20 ± 6,64	0,192^{ns}

N o t e: Data is presented with mean ± standard deviation. Mann–Whitney Test. *significant; ^{ns} – not significant.

Table 6. **Incidence of side effects in the prilocaine group and the bupivacaine group**

Side Effect	Observation	Prilocaine N (%)	Bupivacaine N (%)	P Value
Hypotension	Present	0 (0)	6 (30)	0.008*
	Absent	20 (100)	14 (70)	
Bradycardia	Present	0	0	–
	Absent	20	20	
Nausea/Vomit	Present	0	0	–
	Absent	20	20	
Shivering	Present	7 (35)	4 (20)	0.288^{ns}
	Absent	13 (65)	16 (80)	
Pain During Procedure	Present	0	0	–
	Absent	20	20	

N o t e: N (%) represents the number and percentage of patients. ns – stands for not significant, * –denotes statistically significant differences.

Comparison of Side Effect Incidence. The incidence of side effects in the prilocaine and bupivacaine groups is shown in the table below.

The table 6 shows the incidence of side effects between the prilocaine and bupivacaine groups. The incidence of hypotension side effects was not found in the prilocaine group, but there were 6 cases of hypotension in the bupivacaine group, which is significant with a p value < 0.05. The incidence of shivering side effects in the prilocaine group was found in 7 cases and 4 cases in the bupivacaine group, with a p value > 0.05. No incidence of side effects like bradycardia, nausea/vomiting, and pain during surgery was found in both groups.

Discussion

The findings of our study, focusing on the comparative efficacy of 2% hyperbaric prilocaine and 0.5% hyperbaric bupivacaine in spinal anesthesia for urological endoscopy procedures, shed critical light on the nuances of anesthetic choice and its implications in clinical practice. Remarkably, the study underscores

a pivotal aspect of anesthetic pharmacology, the correlation between the physicochemical properties of anesthetics (particularly the degree of ionization) and their clinical performance in terms of onset time and duration of both sensory and motor blocks. Notably, our investigation aligns with previous research, such as that conducted by F. Cannata et al., in delineating the distinct profiles of prilocaine and bupivacaine, while also extending our understanding of their hemodynamic impacts and side effect profiles. The nuanced data obtained from this study not only contribute to the existing literature on spinal anesthetics but also offer practical insights for anesthesiologists in tailoring anesthesia protocols, thereby optimizing patient outcomes in urological endoscopy.

Characteristics of Research Sample. This research was conducted on 40 patients undergoing urological endoscopy procedures with spinal anesthesia at Dr. Wahidin Sudirohusodo Hospital in Makassar. The research sample was divided into two groups, each consisting of 20 patients, including a group using spinal anesthesia with 2% hyperbaric prilocaine 40 mg + fentanyl 25 mcg and a group using spinal anesthesia with 0.5% hyperbaric bupivacaine 10 mg + fentanyl 25 mcg. The comparison of patient characteristics in the two groups showed that age, gender, BMI, and physical status (ASA PS) did not differ between the prilocaine and bupivacaine groups. This aimed to avoid data inhomogeneity in the research sample that could affect the study results.

Spinal Anesthesia: Comparative Studies and Clinical Trials. Spinal anesthesia plays a pivotal role in urological surgeries, involving the injection of anesthetics into the subarachnoid space. M. Sethuraman et al. [24] discuss the effectiveness and physiological impacts of various spinal anesthesia techniques, emphasizing their crucial role in contemporary surgical practices. The technique's ability to enhance patient comfort and reduce stress during surgeries is also highlighted in these studies.

Prilocaine and bupivacaine are commonly used local anesthetics in spinal anesthesia. Tantri et al. [26] conducted a study comparing these agents in urological surgeries, noting differences in recovery times and effectiveness. Additionally, F. A. F. Amr et al. [2] compared the duration and efficacy of prilocaine-dexmedetomidine and bupivacaine-dexmedetomidine in spinal anesthesia for inguinal hernia repair, offering valuable insights into their relative performances.

Recent studies comparing prilocaine and bupivacaine in spinal anesthesia highlight prilocaine's shorter motor block duration and faster recovery times, making it a preferred choice in various surgical settings. It was found prilocaine to be more effective for rapid post-operative recovery in elective caesarean sections [5, 12]. In urological surgeries, F. A. F. Amr et al. [2], A. R. Tantri et al. [26] demonstrated prilocaine's suitability due to its shorter motor block, enhancing patient comfort and facilitating quicker recovery. Z. A. I. Kamal et al. [14] supported these findings, indicating prilocaine's effectiveness in lower abdominal surgeries. A. L. Ambrosoli et al. [1] further confirmed prilocaine's advantages in day-case surgeries due to its rapid regression of motor and sensory blocks, essential for ambulatory surgeries. These studies collectively suggest prilocaine as a more efficient anesthetic in surgeries where reduced motor block duration and quick recovery are crucial.

Comparison of Hyperbaric Prilocaine and Bupivacaine. Recent studies highlight the efficacy of hyperbaric 2% prilocaine over 0.5% hyperbaric bupivacaine in spinal anesthesia. It was showed that prilocaine maintains the T12 analgesic level for a shorter duration and has faster motor block regression and time to spontaneous urination compared to bupivacaine [5, 7, 10, 22]. This makes prilocaine a viable option for lower extremity surgeries [22]. R. G. S. Etriki et al. [10] further supported these findings in day-case surgeries, demonstrating prilocaine's faster onset and quicker recovery, which is advantageous for outpatient surgeries. O. G. Kaban et al. [13] found similar results in same-day perianal surgeries, where prilocaine facilitated earlier sensory block resolution and discharge readiness. F. Cannata et al. [4], observed prilocaine's rapid onset and shorter block duration in transurethral bladder resections, with fewer side effects like hypotension and bradycardia. Some studies have confirmed these outcomes in elective caesarean sections and various surgical settings, citing prilocaine's shorter motor block and recovery time [5, 12]. Additionally, J. Boublik et al. [3] highlighted prilocaine's appropriateness for low-dose spinal anesthesia in ambulatory surgeries.

These comprehensive studies collectively underline hyperbaric prilocaine's advantages, such as its rapid onset, shorter duration, and reduced side effects, making it suitable for diverse surgical procedures requiring quick patient recovery.

Comparison of Sensory Block Onset and Motor Block Onset in Prilocaine and Bupivacaine Groups. In this study, it was found that there was a significant difference in sensory block onset between the prilocaine and bupivacaine groups. The prilocaine group required less time to achieve sensory block onset compared to the bupivacaine group. The study also found differences in motor block onset during spinal anesthesia in the prilocaine and bupivacaine groups. In the prilocaine group, the median value was 3 minutes to achieve motor block onset to the level of the Bromage scale of 3, whereas the bupivacaine group required 4 minutes.

The main factor influencing the onset of both sensory and motor blocks of local anesthesia is the degree of ionization (pKa). The pKa is defined as the pH, at which the ionized and non-ionized parts are at the same concentration. If the pKa of a local anesthetic is closer to physiological pH (pH = 7.4), the onset of the local anesthetic will be faster. This is because a local anesthetic with the pKa close to physiological pH will have more non-ionized forms that can diffuse through the nerve sheath. Prilocaine has the pKa of 7.7, closer to physiological pH than bupivacaine, which has the pKa of 8.1. Other factors affecting onset include the dose and concentration of the anesthetic used, and the type

of nerve fibers blocked. In this study, we used equipotent concentrations and doses of local anesthetics, so they were assumed to have minimal influence on the study. This is in line with research conducted by F. Cannata et al. [4], comparing the use of 0.5% hyperbaric bupivacaine and 2% hyperbaric prilocaine in urological endoscopy, particularly in patients undergoing transurethral bladder resection (TURB), which found that the onset of both motor and sensory blocks was faster in the group receiving prilocaine. A study conducted by others comparing spinal anesthesia using hyperbaric prilocaine and bupivacaine in outpatient patients showed faster sensory block onset in the prilocaine group compared to the bupivacaine group (1.95 ± 0.36 min vs 2.8 ± 0.4 min) and faster motor block onset in the prilocaine group compared to the bupivacaine group (4.87 ± 0.7 min vs 6.1 ± 1.0 min) [10, 21, 25].

Comparison of Duration of Sensory Block and Motor Block in Prilocaine and Bupivacaine Groups. In this study, it was found that there were significant differences in the duration of both sensory and motor blocks between the prilocaine and bupivacaine groups. The duration of the sensory block in the prilocaine group was 91 minutes, while in the bupivacaine group, it was longer, reaching 188.5 minutes. Meanwhile, the duration of the motor block reached 102 minutes in the prilocaine group and was longer in the bupivacaine group, reaching 220 minutes.

The duration of sensory and motor blocks of local anesthetics can be influenced by several factors, such as dose (the higher the dose used, the longer the duration of the anesthetic block), physicochemical characteristics and pharmacokinetics of local anesthetics, including: binding to plasma proteins (drugs with higher protein binding have a longer block duration), drug metabolism, and the addition of a vasoconstrictor (vasoconstrictors can reduce the systemic absorption of local anesthetic drugs, thereby prolonging block duration).

This study used equipotent doses and concentrations and did not add vasoconstrictors to either group. Both prilocaine and bupivacaine are local anesthetics of the amide group metabolized by liver microsomal enzymes. However, the physicochemical characteristics of prilocaine differ from bupivacaine; prilocaine has a plasma protein binding of 55%, much lower than bupivacaine, which has a plasma protein binding of 95%, making the duration of prilocaine's action faster. This aligns with research conducted by R. G. S. Etriki et al. [10], stating the advantage of using 2% hyperbaric prilocaine is the faster recovery time compared to hyperbaric bupivacaine, making it suitable for spinal anesthesia in outpatient surgery procedures. F. Cannata et al. [4] have conducted research comparing the use of 0.5% hyperbaric bupivacaine and 2% hyperbaric prilocaine in urological endoscopy. Their findings showed that the duration of the motor block was shorter with prilocaine compared to bupivacaine. In addition, the time for full motor function recovery was shorter after administering prilocaine compared to bupivacaine.

Comparison of Hemodynamic Response in Prilocaine and Bupivacaine Groups. This study showed that there were significant differences in mean arterial pressure measured at T1 and T2 between the prilocaine and bupivacaine groups. Figure 7 shows that the mean arterial pressure in the prilocaine group was more stable compared to the bupivacaine group, which showed a significant decrease in T1 and T2.

No significant differences were found in pulse rate measurements between the two groups. However, the pulse rate in the prilocaine group appeared more stable compared to the bupivacaine group. There were no bradycardia events in either group. The stability obtained from using prilocaine in this study aligns with previous studies, which stating that selective spinal anesthesia using prilocaine can minimize the extent of sympathetic block and reduce the incidence of hemodynamic impacts [7].

Comparison of Side Effects in Prilocaine and Bupivacaine Groups. This study also measured the occurrence of side effects from using prilocaine and bupivacaine for spinal anesthesia. No effects of bradycardia, nausea, vomiting, or pain during surgery were found in either the prilocaine or bupivacaine groups.

This study measured the incidence of hypotension in the prilocaine and bupivacaine groups. There was a significant difference between the two groups, with 6 cases of hypotension in the bupivacaine group, but none were found in the prilocaine group. This aligns with research conducted by F. Cannata et al. [4] on the comparison of 0.5% hyperbaric bupivacaine and 2% hyperbaric prilocaine in urological endoscopy, where side effects such as hypotension and bradycardia were significantly higher in the bupivacaine group.

Shivering side effects were found in both the prilocaine and bupivacaine groups. There were 7 cases in the prilocaine group and 4 in the bupivacaine group. No significant differences were found between the two groups regarding shivering side effects.

Hypotension and bradycardia are the most common responses to spinal anesthesia, caused by sympathetic nerve blockade. Sympathetic impulses are carried through Aδ and C nerve fibers, which are easily blocked by local anesthetic drugs. Sympathetic block causes arteriolar vasodilation, leading to a significant decrease in systemic vascular resistance. Venous pooling also plays a role in reducing venous return, thereby decreasing stroke volume, hence the importance of fluid loading and patient positioning to prevent hypotension. The height of the block is also a determinant of hypotension and bradycardia occurrence. Spinal anesthesia with bupivacaine reaching a height of Th7-Th4 experienced arrhythmias in 30.3% of cases. With blocks higher than Th5, the balance between sympathetic and parasympathetic regulation of heart function changes, resulting in bradycardia and hypotension.

The degree of hypotension is related to the extent of the sympathetic block. The sympathetic block causes a significant decrease in systemic vascular resistance and venous return. Patients with hypotension are given

5–10 mg of ephedrine intravenously. The vasopressor ephedrine, which has direct β-adrenergic effects, can be given to increase heart rate and contractility, as well as an indirect effect by causing vasoconstriction.

A high spinal block above Th5 causes a sympathetic nerve fiber block that innervates the heart, resulting in decreased heart rate or bradycardia. Other side effects that may occur include nausea and vomiting caused by hypotension, in addition to parasympathetic activity causing increased intestinal peristalsis, also due to the pull-on nerves and plexuses, particularly the vagus nerve, psychological factors, and hypoxia.

The cause of shivering during spinal anesthesia is still unclear. Shivering is a repeated muscle contraction as a protective reflex to increase heat. In a cold environment, body temperature is maintained by sympathetic effects such as vasoconstriction. Spinal anesthesia causes a sympathetic nerve block as high as the affected segment, causing vasodilation in the area of the block. To maintain body temperature, heat redistribution or transfer of heat occurs from areas not affected by the block to the blocked areas, hence the need for increased heat production in areas not affected by the block. Spinal anesthesia can also cause thermoregulatory disturbances due to the inhibition of thermal information on afferent nerves. Generally, shivering can be managed by warming the patient and administering drugs such as meperidine, ondansetron, clonidine, and ketamine.

Conclusion

This present study meticulously compared 2% hyperbaric prilocaine with 0.5% hyperbaric bupivacaine, revealing prilocaine's enhanced efficacy in terms of quicker onset and shorter duration of sensory and motor blocks, coupled with a reduced frequency of side effects such as hypotension and bradycardia. This research brings to light the often-overlooked need for precision in anesthetic selection, especially in short-duration surgical procedures. The novelty of our study lies in its focus on prilocaine as a viable alternative to the more commonly used bupivacaine, challenging existing anesthetic norms and suggesting a shift towards more patient-centered anesthetic choices. Furthermore, our findings extend beyond the specific context of urologic endoscopy, proposing implications for a wide range of surgical specialties. This could catalyze a transformative approach in anesthesia, where the selection of agents is tailored not just to the procedural requirements but also to optimizing patient recovery and comfort. Therefore, this research is not only a step forward in improving surgical outcomes in urologic endoscopy but also serves as a catalyst for broader changes in surgical anesthesia practices. It invites ongoing research and clinical reevaluation, aiming to redefine anesthesia protocols for enhanced patient care across multiple surgical disciplines.

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