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ORIGINAL ARTICLE

Comparison of perioperative analgesic effectiveness of ultrasound-guided erector spinae plane block and transversus abdominis plane block in patients undergoing laparoscopic nephrectomy

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SUMMARY

Objectives: In this study, we aimed to compare the efficacy of two regional anesthesia methods, transversus abdominis plane (TAP) block and erector spinae plane (ESP) block, for intraoperative and postoperative pain relief in patients undergoing laparoscopic nephrectomy.

Methods: Fifty patients aged 18-80 years with American Society of Anesthesiologists (ASA) classification I-II scheduled for elective laparoscopic nephrectomy were included after ethical approval and informed consent. Patients were randomly assigned to either Group TAP (receiving TAP block) or Group ESP (receiving ESP block). Postoperatively, all patients received patient-controlled analgesia (PCA) with morphine. We evaluated intraoperative hemodynamics, additional opioid use, resting and coughing pain scores (Visual Analog Scales - VAS), time to first PCA dose, postoperative opioid consumption, rescue analgesic needs, opioid side effects, and patient and surgeon satisfaction.

Results: In Group ESP, postoperative VAS scores at 8 hours and during the first mobilization were significantly lower (p=0.019, p=0.004, respectively) compared to Group TAP. Patient satisfaction was notably higher in Group ESP (p=0.014). However, other postoperative parameters were similar between the groups (p>0.05). These findings held true when considering only radical nephrectomies, with no differences in the assessed parameters between simple and partial nephrectomies.

Conclusion: In conclusion, both TAP and ESP blocks demonstrated comparable effectiveness in postoperative pain management for laparoscopic nephrectomies. Nevertheless, due to lower VAS scores during mobilization and higher patient satisfaction, the ESP block appears to be more effective for multimodal analgesia. Further research is required to comprehensively assess their efficacy in laparoscopic radical nephrectomies.

Keywords: Nerve block; nephrectomy; pain management.

Introduction

Postoperative pain is an acute pain that arises in response to surgical trauma, commencing with the surgical incision. Proper assessment and treatment of this pain are crucial. If adequate pain relief is not administered during the postoperative period, it can lead to a rise in complications affecting the cardiac, pulmonary, gastrointestinal, and genitourinary systems, as well as the development of persistent postoperative pain.[1,2] Additionally, this may affect patients' quality of life, prolong hospital stay, and increase morbidity and mortality rates. Moreover, the escalation of complications and prolonged hospitalization contributes to increased healthcare costs.[3]

Opioids, which are frequently preferred drugs in the treatment of postoperative pain, have side effects such as respiratory depression, nausea, vomiting, and slowing of intestinal movements.[4] Despite the less invasive nature of laparoscopic surgeries compared to open surgeries, patients may still necessitate parenteral opioids for postoperative pain control, which can lead to the occurrence of opioid-related side effects.[5]

According to the prevailing approach, postoperative pain is a complex issue influenced by multiple factors, and the use of multimodal analgesia approaches has shown greater effectiveness for its treatment.[6,7] Peripheral nerve blocks play a significant role in

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multimodal analgesia for postoperative pain management. They reduce the need for opioids, which are commonly used for postoperative pain treatment but have various side effects.[4]

Transversus abdominis plane (TAP) block and erector spinae plane (ESP) block are peripheral nerve blocks that can be used for multimodal analgesia in abdominal surgeries. Both blocks have a low risk profile due to the injection site being distant from the neuroaxial area and major vessels and can even be used in patients with clotting problems.[8–10] TAP block has been shown to provide effective analgesia for abdominal surgeries and reduce opioid consumption. In addition, it provides effective analgesia in laparoscopic nephrectomies.[9] ESP block has been shown to be effective in thoracotomies, breast surgeries, abdominal surgeries, and lumbar surgeries and reduce opioid consumption.[11,12] However, to date, there is a lack of studies demonstrating the effectiveness of ESP block in the context of laparoscopic nephrectomies.

We aimed to compare TAP and ESP blocks, which are both easy to apply and safe procedures due to their distance from structures such as major vessels and neuroaxis in patients undergoing laparoscopic nephrectomy. The primary objective of this study was to assess and compare the potential significant differences between the two peripheral nerve blocks, TAP block and ESP block, in various aspects related to intraoperative and postoperative pain management: intraoperative hemodynamic changes, additional opioid requirement, rest, cough, and first mobilization pain scores, opioid requirement, opioid-related side effects, and satisfaction in the postoperative period.

Materials and Methods

This prospective randomized controlled study was conducted at Bursa Uludağ University Health Applications Research Center Hospital between 2020 and 2021, following ethical committee approval from the Bursa Uludağ University Medical Research Ethics Committee (2020-20/13) in accordance with the principles of the Declaration of Helsinki. The study aimed to assess patients who underwent laparoscopic nephrectomy and were classified as American Society of Anesthesiologists (ASA) class I and II.

A total of fifty patients aged between 18 and 80 years were included in the study. However, individuals with known allergies to local anesthetics or suspected coagulopathy, those with a history of injection site infection or previous abdominal surgeries, serious neurological or psychiatric disorders, severe cardiovascular disease, liver failure, kidney failure (glomerular filtration rate<15 ml/min/1.73 m^2), and those with chronic opioid use were excluded from the study.

Before the surgery, outpatient evaluation sessions were conducted to provide essential information to the patients. This information covered topics such as general anesthesia, ESP block, TAP block, the use of the visual analog scale (VAS) for pain assessment, and the patient-controlled analgesia (PCA) device and its administration process. Both written and verbal consents were obtained from the patients during this stage.

To ensure fair and unbiased distribution of patients into different treatment groups, a closed envelope method was used for randomization. This resulted in 25 patients being assigned to the ESP group and another 25 patients to the TAP group. Regional blocks in both groups were performed by the same anesthesiologist.

For the induction of general anesthesia, 0.05 mg/kg of midazolam (Zolamid®, Defarma, Ankara, Türkiye), 2 mcg/kg of fentanyl (Talinat®, Vem, İstanbul, Türkiye), 1 mg/kg of lidocaine (Aritmal 2%® Osel, İstanbul, Türkiye), 2 mg/kg of propofol (Propofol 1% Fresenius®), and 0.6 mg/kg of rocuronium (Myocron®, Vem, İstanbul, Türkiye) were administered to the patients. Sevoflurane (Sevorane® Liquid 100%, AbbVie, Queenborough Kent, England) was used for anesthesia maintenance. For peripheral nerve block application, an ultrasound machine (Logic e®, GE, Boston, USA) with an 8–12 MHz linear probe and a needle visible on the ultrasound (Echoplex plus®, 50 mm 22G, Vygon, France) were used.

Under general anesthesia, patients in the ESP group were positioned in either the left or right lateral decubitus position, depending on the side of the surgical procedure. The T10 spinous process was identified and marked through manual examination.

Under sterile conditions, ultrasound imaging was used to locate the T10 spinous process in the transverse plane, after which the ultrasound probe was advanced 3 cm towards the side where the block was to be performed. The transverse process was visualized, and the probe was then rotated by 90 degrees. The trapezius muscle and erector spinae muscle appeared hypoechoic, while the transverse process appeared hyperechoic with an acoustic shadow underneath.

Using an in-plane technique, the needle was inserted between the erector spinae muscle and the transverse process. 50 mg bupivacaine (Buvasin®, Vem, İstanbul, Türkiye) was diluted with 0.9% NaCl solution to make a total of 20 ml for administration. To confirm the correct needle placement, hydrodissection was performed using 1–2 ml of saline. Subsequently, 20 ml of the bupivacaine solution was administered. After the procedure, the spread of the local anesthetic within the fascia between the erector spinae muscle and the transverse process was observed with ultrasound.

For the TAP group, the posterior approach was applied. Following general anesthesia, the patients were placed in a supine position under sterile conditions. The ultrasound probe was positioned transversely between the iliac crest and costal margin on the midaxillary line of the surgical side. The external oblique muscle, internal oblique muscle, and transversus abdominis muscle appeared hypoechoic, while the hyperechoic fascial planes between them were clearly visualized. 50 mg bupivacaine was diluted with 0.9% NaCl solution to make a total of 20 ml for administration. To confirm the correct needle placement, hydrodissection was performed using 1–2 ml of saline. Subsequently, 20 ml of the bupivacaine solution was administered. Following the procedure, ultrasound was used to observe the spread of the local anesthetic within the fascial plane between the internal oblique abdominal muscle and the transversus abdominis muscle.

In cases where there was a 20% increase in intraoperative blood pressure and heart rate, 50 mcg of intravenous fentanyl was administered. Additionally, as a routine antiemetic prophylaxis during the intraoperative period, all patients received 10 mg of metoclopramide 30 minutes before the end of surgery. Patients were extubated and transported to the recovery unit after receiving 2 mg/kg of sugammadex (Bridion®, MSD Pharma, USA) for the antagonization of rocuronium.

Intravenous PCA was used for postoperative pain control. A morphine (Morphine HCL®, Galen Pharma, İstanbul, Türkiye) solution was prepared at a concentration of 1 mg/ml. The device was set with no basal infusion or loading dose, a bolus dose of 2 ml, and a lockout period of 15 minutes. Patients were transported to the ward when their vital signs were stable and their Modified Aldrete Score was ≥9. If the patients had a VAS score ≥4 or complained of pain in the recovery unit, a bolus dose of morphine was administered using the PCA device.

If the VAS score was still≥4 despite the PCA, rescue analgesia was planned to be administered. Initially, 1 g of intravenous paracetamol (Partemol®, VEM, İstanbul, Türkiye) was given. If the VAS score remained≥4, 1 mg/kg intramuscular meperidine (Aldolan®, G.L. Pharma GmbH, Lannach, Austria) was planned as the second option.

The demographic data of the patients, hemodynamic data (mean arterial pressure, heart rate, oxygen saturation) at 30-minute intervals during the intraoperative period, and additional opioid use were recorded. Resting VAS and coughing VAS scores were recorded at postoperative 0, 15, 30, 45 minutes, and 1, 2, 4, 8, 12, 16, and 24 hours. Additionally, the time of the first use of PCA, total morphine consumption, rescue analgesic requirements, pain during the first mobilization, and opioid side effects were recorded at the same intervals (such as nausea-vomiting, constipation, respiratory depression, sedation, urinary retention, and allergy). Patient and surgeon satisfaction were also recorded by an anesthesiologist who was blinded to both groups using a 5-point Likert scale (1: Very Dissatisfied, 5: Very Satisfied).

Statistical Analyses

The statistical analysis of the study was conducted using the SPSS 21.0 package program. Categorical variables were summarized by number and percentage, and continuous numerical variables by mean±standard deviation or median values. Pearson

Table 1. Distribution of patient and clinical characteristics by groups in cases undergoing laparoscopic nephrectomy

	ESP (n=25)			TAP (n=25)			p
	n	%	Mean±SD	n	%	Mean±SD	
Gender							0.571
Male	13	52		11	44		
Female	12	48		14	56		
Age (year)			54.4±12.1			52.4±15.9	0.633*
BMI (kg/m^2)			27.7±3.7			26.4±4.9	0.272*
ASA score							0.325
I	10	40		12	48		
II	15	60		13	52		

Independent samples t-test was used, and chi-square test was used for other comparisons. SD: Standard deviation ASA: American Society of Anesthesiologists physical status classification; BMI: Body mass index; ESP: Erector spinae plane; TAP: Transversus abdominis plane.

Chi-square test and Fisher's Exact test were used to compare categorical variables between groups. The normality of continuous numerical variables was checked using the Shapiro-Wilk test. Independent sample t-test was used to compare normally distributed numerical variables between two independent groups, and the Mann-Whitney U test was used to compare non-normally distributed numerical variables between two independent groups.

Bar graphs were used for visualizing parametric data, box-line graphs for non-parametric data, and linear graphs for measurements taken at different times. A p-value<0.05 was considered as the level of significance.

Results

Intraoperative and postoperative characteristics of ESP and TAP block in 50 patients undergoing laparoscopic nephrectomy (Group TAP, n=25; Group ESP, n=25) were evaluated. Patient demographic characteristics are shown in Table 1. Operation types and durations were found to be similar (p>0.005). Three patients in the TAP group and four patients in the ESP group required an additional 50 µg fentanyl during the intraoperative period, and there was no significant difference between the groups (p=0.687).

Comparing the intraoperative parameters such as mean arterial pressure, heart rate, and peripheral oxygen saturation, no statistically significant difference was found between the ESP and TAP groups at all measured times (p>0.05).

There was no statistically significant difference between the ESP and TAP groups regarding the time to first request for analgesia after surgery and total morphine consumption (p>0.05). Notably, two patients in the ESP group did not require any analgesia for 24 hours. Since our evaluation was conducted within the first 24 hours, the first PCA usage time was assessed in 23 patients in the ESP group. Considering that the remaining two patients might have used PCA at the end of the 24th hour, the analysis was extended to all 25 patients, and no significant difference was observed between the two groups (p>0.05). Furthermore, none of the patients in either study group required rescue analgesia.

In the postoperative period, VAS scores were evaluated at rest, during coughing, and during the first request for analgesia. At the postoperative 8th hour, the resting VAS score in the TAP group was significantly higher compared to the ESP group (p=0.019). VAS scores at other measurement times were found to be similar between the groups (p>0.05) (Fig. 1, 2).

The VAS score of cases during their first mobilization was 3 (2–6) in the TAP group and 2 (2–4) in the ESP group (Median [min–max]). The score in the TAP group was significantly higher compared to the ESP group (p=0.004).

When the values and distributions of postoperative PCA usage in the study groups were compared at all measurement times, they were found to be similar (p>0.05) (Fig. 3).

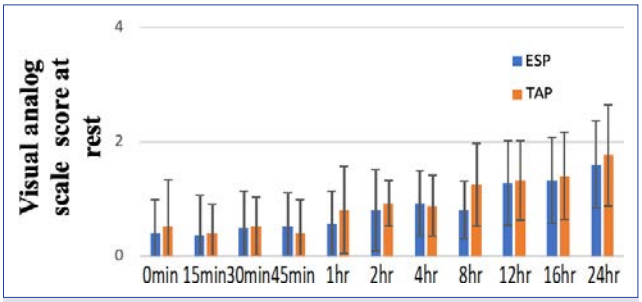

Figure 1. Graphical representation of the distribution of postoperative resting visual analog scale scores at measurement times.

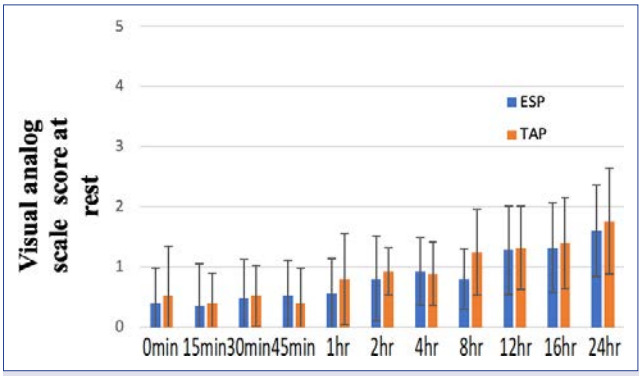

Figure 2. Graphical representation of the distribution of postoperative coughing visual analog scale scores at measurement times (mean±standard deviation).

There were no cases of respiratory depression, sedation, constipation, urinary retention, or allergy related to systemic opioid use, while nausea-vomiting was observed in 4% (n=2) of the cases. Although the two patients with nausea-vomiting were in the TAP group, there was no significant difference between the ESP and TAP groups in terms of the incidence of nausea-vomiting (p=0.149).

Patient satisfaction was significantly higher in the ESP group than in the TAP group (p=0.014), while no significant difference was detected between the groups in terms of surgeon satisfaction (p=0.162).

Subgroup Analysis

For subgroup analysis based on the type of surgery, the study cases were evaluated as those who underwent either laparoscopic partial or simple nephrectomy (n=25) and those who underwent laparoscopic radical nephrectomy (LRN) (n=25).

In the subgroup analysis of cases who underwent LPSN surgery, there was no statistically significant difference in terms of patient and clinical characteristics (p>0.05). In the analysis of all parameters in the study between the ESP and TAP groups, no difference was found between the two groups.

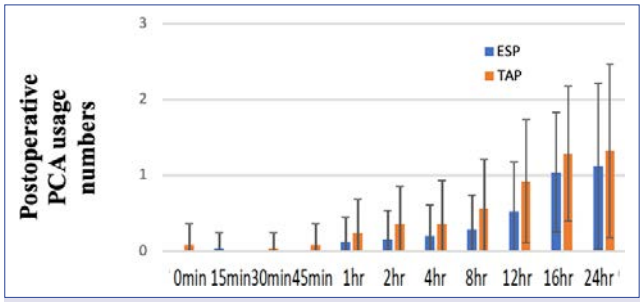

Figure 3. Graphical representation of the distribution of postoperative mean patient-controlled analgesia usage numbers at measurement times (mean±standard deviation).

In the subgroup analysis of cases who underwent LRN surgery, there was no statistically significant difference in terms of patient and clinical characteristics (p>0.05).

In the LRN group, the VAS score during the first mobilization, which was defined as 3 (2–4) in the ESP group and 3.5 (3–5) in the TAP group, was significantly higher in the TAP group compared to the ESP group (p=0.002). In addition, the number of IV PCA usages in the postoperative 4th hour was 0 (0–1) in the ESP group and 1 (0–1) in the TAP group, and it was significantly higher in the TAP group (p=0.008).

Patient satisfaction was found to be 5 (4–5) in the ESP group and 4 (2–5) in the TAP group, and patient satisfaction was higher in the ESP group (Median [min–max]) (p=0.023). There was no significant difference in other analyses in the LRN subgroup.

Discussion

We conducted a prospective, randomized, controlled study comparing TAP and ESP blocks in patients undergoing laparoscopic nephrectomy. Prior to our study, there were no existing studies directly comparing both blocks in the context of laparoscopic nephrectomy surgery. Instead, case reports for the ESP block and studies for the TAP block in providing multimodal analgesia in laparoscopic nephrectomies were available in the literature.[13–17]

A meta-analysis by Zayed et al.[10] in urological surgeries showed that the TAP block group had lower resting and mobilization pain scores and consumed

fewer opioids in the first 24 hours after surgery. In addition, a study by Yeap et al.[18] comparing a single-dose TAP block with continuous infusion via catheter found no difference in VAS scores. These findings indicate that the TAP block is an important part of multimodal analgesia in laparoscopic nephrectomies, and a single-dose administration can be sufficient.

Case reports by Piliego et al.,[19] Canturk et al.,[20] Santonastaso et al.,[21] and Kim et al.[22] also demonstrated the efficacy of the ESP block in nephrectomies. Additionally, Aksu et al.[23] reported its effectiveness in 2 pediatric cases. Notably, the ESP block is effective in both visceral and somatic pain through ventral and dorsal rami, suggesting it may be more effective than the TAP block.

Assessing intraoperative hemodynamic parameters is vital in preserving stability during surgery. Abdelhamid et al.[24] compared TAP block, ESP block, and opioid analgesia during sleeve gastrectomy surgeries. Both block groups had significantly lower heart rate and mean arterial pressure compared to the opioid group, with no significant difference between the two blocks except at the 30th minute. Our study yielded similar results, finding no significant difference in hemodynamic parameters when comparing the two blocks.

The use of additional intraoperative opioid doses can lead to increased opioid-related side effects in the postoperative period. Ozdemir et al.[25] compared the efficacy of TAP and ESP blocks in laparoscopic cholecystectomy surgery and reported significantly higher intraoperative fentanyl requirements in the TAP block group. In our study, although a few patients in both groups required additional fentanyl, there was no significant difference between the groups. Differences in surgical procedures and TAP block techniques might account for this variation.

The importance of pain scales in the postoperative evaluation of peripheral nerve blocks, which are a crucial component of multimodal analgesia, is significant. Boules et al.[26] compared TAP and ESP blocks in elective cesarean sections and found that the VAS scores at rest and with coughing were significantly lower in the ESP block group at 8 and 12 hours. However, the VAS scores were similar at other time points. Kamel et al.[27] compared TAP and ESP blocks in total abdominal hysterectomy and found that the ESP block group had significantly lower scores at all measurement times.

In our study, we only found a significant difference in the resting VAS score in the ESP group at the 8th hour. We did not find a significant difference in the rest and coughing VAS scores at other measurement times. The variability in VAS scores in these studies suggests that differences in the type of surgery performed, the variability of block effectiveness, or the use of additional analgesics in the studies may contribute to the results.

Peripheral nerve blocks, as part of multimodal analgesia, aim to decrease opioid consumption. In a study by Ozdemir et al.,[25] the first analgesic requirement was earlier in the TAP block group. Similarly, Malawat et al.[28] found a shorter time to the first analgesic requirement in the TAP group for cesarean surgery.

Our study observed two patients in the ESP group with a maximum VAS score of 2 within the first 24 hours, who did not require PCA during the follow-up period. All patients in the TAP group used PCA, but there was no significant difference between the groups in terms of the time to the first PCA usage.

When comparing opioid consumption within the first 24 hours postoperatively, Altıparmak et al.[29] found tramadol consumption to be significantly higher in the TAP block group, whereas Boules et al.[26] reported significantly lower tramadol consumption in the ESP block group. In our study, total morphine consumption within the first 24 hours was lower in the ESP group, but no significant difference was observed between the TAP and ESP groups. Additionally, no significant difference was found in PCA usage between the two groups at various time points.

The effectiveness of peripheral nerve blocks in the postoperative period is expected to reduce opioid-related side effects. In a study by Kamel et al.,[27] nausea and vomiting were more common in the TAP block group, but no significant difference was found between the TAP and ESP groups. In our

study, nausea or vomiting was observed in only 2 patients in the TAP group, and no significant difference in other opioid-related side effects was found between the groups. The routine administration of antiemetics to all patients during surgery might have contributed to the lower incidence of nausea or vomiting in our study.

Patient satisfaction is an important indicator of the effectiveness of peripheral nerve blocks. In Boules et al.'s[26] study, patient satisfaction did not differ between the TAP and ESP block groups. In our study, surgical satisfaction was high in both groups, with no significant difference between them. However, patient satisfaction was significantly higher in the ESP group, potentially due to lower VAS scores during the first mobilization, indicating increased comfort and reduced pain for patients.

In a recent meta-analysis study, Liheng et al.[30] compared ESP block and TAP block in abdominal surgeries. Although they found reduced opioid consumption in the first 24 hours, improved pain scores, and reduced postoperative nausea and vomiting in the ESP block compared to the TAP block, there were no significant clinical differences between the two groups.

In our study, we found a notable difference in the resting VAS score in the ESP group at the 8th hour, observed two patients in the ESP group who did not require PCA during the follow-up period, and patient satisfaction was higher in the ESP group. However, there were no clinically significant differences overall. These results taught us that the effectiveness of both blocks was not superior to one another.

Although our study focused on laparoscopic nephrectomies, we included different types of nephrectomies and performed subgroup analysis. When comparing TAP and ESP blocks in the laparoscopic radical nephrectomy (LRN) subgroup, similar to the main group results, the ESP group had lower VAS scores during the first mobilization and higher patient satisfaction. The ESP group also had significantly lower PCA usage at 4 hours. This suggests that the patients in the LRN subgroup may have influenced the overall results of the study.

Limitations

Our study had some limitations, such as not evaluating the dermatome distribution, not measuring local anesthetic concentration in the blood, and the inability to assess early mobilization due to routine mobilization timing. Nonetheless, our findings indicate that the ESP block may be more effective than the TAP block in multimodal analgesia for laparoscopic nephrectomies. Further research is needed to evaluate the effectiveness of both blocks in all laparoscopic nephrectomies and LRN surgeries.

Conclusion

The effectiveness of TAP and ESP blocks in our study was generally found to be similar. However, in the postoperative period, the ESP group had statistically lower VAS scores at the 8th hour of rest and during the first mobilization, as well as higher patient satisfaction. This suggests that the ESP block may be more effective than the TAP block in multimodal analgesia.

Furthermore, our study's statistical results for TAP and ESP blocks were consistent with those of the main group and the LRN subgroup. It shows that the LRN subgroup is the primary factor influencing the main study results. Therefore, we concluded that more research is needed to evaluate the effectiveness of both blocks in all laparoscopic nephrectomies and LRN surgeries.

Ethics Committee Approval: The Bursa Uludağ University Clinical Research Ethics Committee granted approval for this study (date: 11.11.2020, number: 2020-20/13).

Authorship Contributions: Concept – NÖ, SA, SG, AG; Design – NÖ, SA, SG, AG; Supervision – NÖ, SA, SG; Data collection and/or processing – NÖ; Analysis and/or interpretation – NÖ, AG; Literature review – NÖ; Writing – NÖ; Critical review – NÖ, SA.

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