Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1227991

Anatolian Curr Med J 2023; 5(1); 59-64

Could niaouli aromatherapy oil be an option in the treatment of urinary tract infections in hemiplegic patients?

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Cite this article as: Aygün Bilecik N, Yaşa Öztürk G. Could niaouli aromatherapy oil be an option in the treatment of urinary tract infections in hemiplegic patients?. Anatolian Curr Med J 2023; 5(1); 59-64.

ABSTRACT

Aim: Stroke remains a massive public health burden, affecting approximately 795,000 individuals each year. It is the leading cause of long-term disability in adults and the third leading cause of death in developed countries. After a stroke, medical complications are common and can prolong hospital stay, worsen stroke outcomes, and increase the cost of care. The most common medical complications related to stroke are infections, including pneumonia and urinary tract infection (UTI). Intervention strategies previously investigated in these cases and other patient populations include prophylactic antibiotics, antiseptic-impregnated catheters, and quality improvement interventions to reduce inappropriate catheterization. In addition, in recent years, complementary and alternative medicine methods, such as *Melaleuca viridiflora* (also known as tea tree or Niaouli oil) have become increasingly popular. The primary uses of this oil have historically been associated with the antiseptic and anti-inflammatory effects of this plant. In this study, we investigated the efficacy of M. viridiflora (Niaouli) oil in the treatment of UTIs in stroke patients.

Material and Method: We did not find any study in the literature on the effects of Niaouli aromatherapeutic oil on UTIs, which are common in hemiplegic patients; therefore, we planned the current study. The hospital records were screened to identify patients treated at the Physical Therapy and Rehabilitation Unit of Health Sciences University Adana City Training and Research Hospital, who were diagnosed with UTIs during their follow-up and recommended Niaouli aromatherapy oil as a complementary treatment. The oil was supplied by the patients themselves. As the method of use, the patients were asked to prepare a washing solution by dripping 10 drops of Niaouli oil into 1 liter of water. The patients were recommended to wash the perineum area three times a day with this solution for 20 days.

Results: The mean age of the hemiplegic patients evaluated in the study was 51.55±19.20 (min=18, max=77) years. Of the patients, 72.7% were male, 42.4% had an American Spinal Injury Association classification of C, 54.5% had spontaneous bladder emptying, and 30.3% had stage 1, 21.1% had stage 2, and 3.0% had stage 3 spasticity. Leukocyte esterase and leukocyte in urine and sedimentation values statistically significantly decreased in the post-treatment period compared to the pre-treatment period.

Conclusion: UTI is a common complication in stroke patients. In this study, it was determined that the efficacy of the treatment of UTIs increased, and the use of antibiotics significantly decreased with the utilization of the fungicidal and bactericidal effects of M. viridiflora (Niaouli) aromatherapy oil.

Keywords: Stroke, urinary tract infection, *Melaleuca viridiflora* (Niaouli), aromatherapy

INTRODUCTION

In terms of frequency and importance, stroke ranks first among neurological diseases seen in adulthood. According to the latest World Health Organization report, stroke is the second leading cause of death across the world (1). It is also globally the most common and serious neurological problem. Stroke patients become prone to many complications, both due to the stroke itself and the disability caused by this condition (2). After a stroke, medical complications are common and can prolong hospital stay, worsen patient outcomes, and increase the cost of care (3). Among the most common medical complications related to stroke are infections, such as pneumonia and urinary tract infection (UTI) (4). UTI is a common cause of morbidity in the general population, but stroke patients are at a higher risk of infections and may have more negative significant outcomes (5).

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Received: 01.01.2023 **Accepted:** 11.01.2023

The use of Foley catheters is a well-defined risk factor for healthcare-associated UTIs, and their inappropriate use may be more common in stroke patients, further increasing the risk of UTIs (5). Stroke patients, whether catheterized or not, are at a particularly high risk of developing UTIs in hospital, and the incidence of UTIs among these patients is more than double compared to the general medical and surgical populations (6). Immunosuppression that develops after a stroke, urinary retention, urinary incontinence, and catheterization are the main reasons for the increased risk of UTIs during this period (6-8). However, through some interventions, the development of post-stroke UTIs can be reduced. The use of prophylactic antibiotics, antiseptic-coated catheters, silver alloy catheters, and condom use in male patients, as well as the reduction of Foley catheter use are among the methods applied to reduce the risk of UTIs that may develop after a stroke (9-10). In addition, complementary medicine methods, including aromatherapy and phytotherapy have been increasingly used for antiseptic purposes in recent years. In particular, *Melaleuca viridiflora* (also known as tea tree or Niaouli) oil has become popular. This essential oil has been used in Australia for nearly a century, but it is now also becoming available across the world both as pure oil and as an active ingredient in a number of products. The primary uses of tea tree oil (TTO) have historically been based on the antiseptic and anti-inflammatory effects of the plant. TTO contains terpene hydrocarbons, mainly monoterpenes, sesquiterpenes, and related alcohols (11).

Belonging to the Myrtaceae family, tea tree (*Melaleuca alternifolia* [*M. alternifolia*] Cheel) is an herb with yellow or purple flowers and needle-like leaves. The terpinen-4-ol chemotype of *M. alternifolia* typically contains 30% and 40% of terpinen-4-ol (12) and is used in commercial TTO production. Despite the inherent variability of commercial TTO, to date no significant difference has been reported in its bioactivity in vitro or in vivo. It has been suggested that the oil obtained from a certain *M. alternifolia* clone enhances microbicide activity (13). The antibacterial action mechanism of TTO is based on its hydrocarbon structure and accompanying lipophilic structure. The hydrocarbon structure acts by disrupting the biological membranes of microorganisms (14). There are studies investigating the bactericidal effects of TTO on *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* (15-17). Recent studies have also shown that *Candida albicans*, a number of yeasts, dermatophytes, and other filamentous fungi are susceptible to TTO (18,19). TTO also has antiviral and antiprotozoal activity (20,21). Although there are many studies demonstrating the antimicrobial, antiviral, antifungal, and antiprotozoal properties of TTO, we did not find any study in the literature concerning its efficacy in UTIs.

In this study, we investigated the efficacy of the aromatherapeutic oil of *Melaleuca viridiflora* (Niaouli), a TTO derivative, in the treatment of UTI, a common complication after a stroke.

MATERIAL AND METHOD

This study was carried out with the permission of Adana City Hospital Clinical Researches Ethics Committee (Date: 08.09.2022, Decision No: 2136). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

To the best of our knowledge, there is no study in the literature on the effects of the Niaouli aromatherapeutic oil on UTIs, which are common in hemiplegic patients.

Therefore, we planned the current study. Patients who were treated in the physical therapy service, who had symptoms of urinary system infection such as dysuria, urinary incontinence, fever, or who were found to have urinary system infection in the urinalysis were included in the study.

The hospital records were screened to identify patients treated at the Physical Therapy and Rehabilitation Unit of Health Sciences University Adana City Training and Research Hospital, who were diagnosed with UTIs during their follow-up and recommended Niaouli aromatherapy oil as a complementary treatment. The oil was supplied by the patients themselves. As the method of use, the patients were asked to prepare a washing solution by dripping 10 drops of Niaouli oil into 1 liter of water. The patients were recommended to wash the perineum area three times a day with this solution for 20 days. The patients' demographic characteristics, length of hospital stay, bladder emptying methods (spontaneous bladder emptying, Foley catheter use, clean intermittent catheterization, and diaper use), disease symptoms, hemogram, sedimentation, and CRP values, complete urinalysis and urine culture results before and after Niaouli oil use were recorded from the patient files. The examination, test, treatment, and clinical evaluations of the patients were undertaken by the principal researchers working at the hospital. The data of patients using standardized Niaouli oil were screened (Niaouli certifications: EEC ORGANIC certified by FR-BIO-01.N'CAS EINECS: 132940-73-9).

The chromatographic analysis of Niaouli oil was performed with the combined headspace solid-phase microextraction (HS/SPME) and gas chromatography-mass spectrometry (GC/MS) methods for the determination of the volatile compounds of the oil. The extraction of essential oils was performed by treating the oil with 5 M $CaCl_2$ on a magnetic

stirrer at 3°C for 20 minutes in a standard headspace glass bottle (Supelco, 75 mm×23 mm). Analyses were undertaken with three replications. The volatiles were absorbed by polydimethylsiloxane (PDMS) using an SPME needle (Supelco, Bellefonte, PA). PerkinElmer GC (Clarus 600) equipped with HP-5 MS (30 m×0,25 mm×0,25 µm) and a fused-silica capillary column were used for the separation of volatiles. The carrier gas was helium (0,6 ml/min). The injection temperature was set as 280°C. The initial column heating was 40°C for 2 minutes, followed by an increase of temperature to 250°C at a rate of 5°C/minute, at which the sample was kept for 20 minutes. Compounds were determined by obtaining their mass spectra and using the NIST, Wiley, and flavor libraries according to their retention time.

The following exclusion criteria were used: other neurological diseases that may cause neurogenic bladder other than hemiplegia, dementia diagnosis, history of tumors and infections, diagnosis of polyneuropathy, advanced spasticity, and history of prostate and bladder disease.

In statistical analysis, continuous variables were expressed as mean±standard deviation and/or median (minimum-maximum) values, and categorical data as numbers and percentages. The normality of the distribution continuous variables was checked using the Kolmogorov-Smirnov goodness-of-fit test. Since the data were not suitable for a normal distribution, intra-group comparisons before and after treatment were made with the Wilcoxon signed-rank test. The McNemar test was conducted to compare categorical data before and after treatment. Statistical analyses were performed using IBM SPSS version 26.0 (IBM Corporation, Armonk, NY, USA). The statistical significance level was accepted as $p < 0.05$.

RESULTS

The mean age of the hemiplegic patients evaluated within the scope of the study was 51.55±19.20 (min=18, max=77) years. Of the patients, 72.7% were male, 54.5% had spontaneous bladder emptying, and 30.3% had stage 1, 21.1% had stage 2, and 3.0% had stage 3 spasticity (**Table 1**).

Leukocyte esterase and leukocyte in urine and sedimentation values statistically significantly decreased in the post-treatment period compared to the pre-treatment period (p<0.001, p<0.001, and p=0.005, respectively). C-reactive protein and white blood cell count also decreased after treatment compared to the pre-treatment values, and the differences were close to statistical significance (p=0.079 and p=0.054, respectively) (**Table 2**).

Table 1. Demographic and clinical characteristics of the patients

	Mean±Sd
Age (years) (mean±Sd)	51.55±19.20
Length of hospital stay (day) [median (min-max)]	15 (2-82)
	N (%)
Gender (n, %)	
Female	9 (27.3%)
Male	24 (72.7%)
Spasticity	
No	15 (45.5%)
Stage 1	10 (30.3%)
Stage 2	7 (21.1%)
Stage 3	1 (3.0%)
Bladder emptying method	
Spontaneous	18 (54.5%)
Catheter	11 (33.3%)
4x1 CIC	3 (9.1%)
6x1 CIC	1 (3.0%)
Total	33 (100.0%)

CIC: clean intermittent catheterization

Table 2. Laboratory parameters before and after treatment

	Before treatment	After treatment	p
Leukocyte esterase in urine [Median (min-max)]	2 (0-3)	0 (0-3)	<0.001*
Leukocyte in urine [Median (min-max)]	10 (1-382)	4 (0-464)	<0.001*
Erythrocyte in urine [Median (min-max)]	5 (1-182)	4 (0-348)	0.175*
Sedimentation [Median (min-max)]	23 (4-60)	14 (1-60)	0.005*
C-reactive protein [Median (min-max)]	22 (3-214)	13 (1-262)	0.079*
White blood cell count [Median (min-max)]	8,400 (4,600-18,000)	7,500 (4,000-14,000)	0.054*

*Wilcoxon signed-rank test

While there was growth in the urine culture of 60.6% of the patients in the pre-treatment period, this rate decreased to 27.3% after treatment, indicating a significant difference (p=0,003). It was also determined that the rate of patients with fever significantly decreased from 28,1% in the pre-treatment period to 3.1% after treatment (p=0.008). In rate of patients with urethral discharge was 28.1% before treatment and 12.1% after treatment, and the difference was significant (p=0.021). Urinary incontinence was seen at a rate of 60.6% in the pre-treatment period, and this rate significantly decreased to 33,3% after treatment (p=0,012). Although there was a decrease in the complaints of increased reflex sweating and spasticity in the post-treatment period, the difference was not statistically significant when compared to the pre-treatment rates (p=0,063 and p=0,219, respectively) (**Table 3**)

The rate of patients that developed skin lesions after treatment was determined as 18,2% (**Figure 1**).

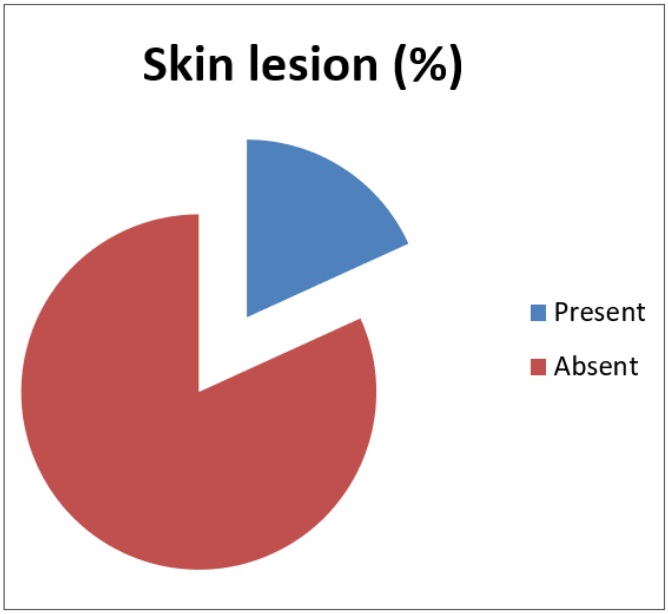

Figure 1.

Table 3. Comparison of patient symptoms before and after treatment

Growth in urine culture (post-treatment)	**Growth in urine culture (pre-treatment)**		**Total**	**p**
	Absent	**Present**		
Absent	12 (92.3%)	12 (60.0%)	24 (72.7%)	0.003*
Present	1(7.7%)	8 (40.0%)	9 (27.3%)	
Total	13 (39.4%)	20 (60.6%)	33 (100.0%)	
Fever (post-treatment)	**Fever (pre-treatment)**		**Total**	
	Absent	**Present**		
Absent	23 (100.0%)	8 (88.9%)	31 (96.9%)	0.008*
Present	0(0.0%)	1 (11.1%)	1 (3.1%)	
Total	23 (71.9%)	9 (28.1%)	32 (100.0%)	
Urethral discharge (post-treatment)	**Urethral discharge (pre-treatment)**		**Total**	
	Absent	**Present**		
Absent	20 (95.2%)	9 (75.0%)	29 (87.9)	0.021*
Present	1(4.8%)	3 (25.0%)	4 (12.1)	
Total	21 (63.6%)	12 (36.4%)	33 (100.0)	
Reflex sweating (post-treatment)	**Reflex sweating (pre-treatment)**		**Total**	
	Absent	**Present**		
Absent	24 (100.0%)	5 (55.6%)	29 (87.9)	0.063*
Present	0(0.0%)	4 (44.4%)	4 (12.1)	
Total	24 (72.7%)	9 (27.3%)	33 (100.0)	
Urinary incontinence (post-treatment)	**Urinary incontinence (pre-treatment)**		**Total**	
	Absent	**Present**		
Absent	12 (92.3%)	10 (50.0%)	22 (66.7)	0.012*
Present	1(7.7%)	10 (50.0%)	11 (33.3)	
Total	13 (39.4%)	20 (60.6%)	33 (100.0)	
Increased spasticity (post-treatment)	**Increased spasticity (pre-treatment)**		**Total**	
	Absent	**Present**		
Absent	20 (95.2%)	5 (41.7%)	25 (75.8)	0.219*
Present	1(4.8%)	7 (58.3%)	8 (24.2)	
Total	21 (63.6%)	12 (36.4%)	33 (100.0)	

*McNemar test

DISCUSSION

Infections, especially UTIs and pneumonia are among the most common complications after a stroke (4). UTIs observed after a stroke have been associated with regression in neurological status, mortality, increased disability, and prolonged hospital stay (22). In this study, the average length of hospital stay was 15 days and Leukocyte esterase and leukocyte in urine and sedimentation values statistically significantly decreased in the post-treatment period compared to the pre-treatment period ($p<0.001$, $p<0.001$, and $p=0.005$, respectively). C-reactive protein and white blood cell count also decreased after treatment compared to the pre-treatment values, and the differences were close to statistical significance ($p=0.079$ and $p=0.054$, respectively) (**Table 2**).

The typical manifestations of UTIs include dysuria, frequent urination or urgency, suprapubic pain, or flank pain often accompanied by fever, chills, and/or high peripheral leukocyte counts. Urine culture analysis is important in the diagnosis of catheter-related UTIs. Similar to the literature, in this study, fever, dysuria, and urinary incontinence complaints were predominant in patients with a diagnosis of UTIs. A significant improvement was observed in these complaints after Niaouli treatment. Urinary leukocyte esterase, urinary leukocyte count, and sedimentation rate, which are markers of UTI, were also found to significantly decrease in the post-treatment period compared to the pre-treatment values.

In order to reduce the risk of UTIs, the use of indwelling urinary catheters should be avoided as much as possible (23). In the current study, 33,3% of the patients with post-stroke UTIs were using catheters. External catheter systems (e.g., condom catheters for men and adhesive urine collection bags for women) and intermittent catheterization are alternatives that may be associated with a lower risk of UTIs compared to indwelling urethral catheters.

The use of antibiotics and preventive measures play an important role in the treatment of UTIs. Resistance to antibiotics in recent years has led to a search for other treatment alternatives. In recent years, alternative treatment methods, such as aromatherapy have been used as antimicrobials (13). However, we did not find any study in the literature on the use of aromatherapy in the treatment of UTIs. Our results revealed that while 60,6% of the patients had growth in urine culture in the pre-treatment period, this rate decreased to 27,3% after Niaouli treatment, and the difference between the two evaluations was significant (p=0,003).

Preclinical and clinical data regarding the antimicrobial activity of essential oil from Melaleuca spp. plants show

their activity against a wide range of Gram-positive and Gram-negative bacteria, fungi, and yeasts. The first clinical studies undertaken for this purpose were on acne treatment and dental applications (24,25). In this study, the growth rate in urine culture in stroke patients statistically significantly decreased after treatment. In light of these findings, we concluded that Niaouli oil could be an alternative in the treatment of UTIs.

Except for in vitro experiments, there are fewer clinical studies on skin sensitivities that may occur with the use of TTO. A few cases of contact dermatitis have been recorded during the topical use of this oil, but it should be noted that the oil was used in a concentrated form or in combination with other essential oils in these cases. In a study in which 28 individuals used a 25% TTO solution, sensitization was observed in only three participants (26). In other cases reported in the literature, reactions cannot be solely attributed to the use of TTO, since it was not used alone (27). In the current study, the rate of patients that developed skin lesions after Niaouli treatment was determined as 18,2%; however, it is not possible to conclude that this was solely related to the use of this oil. It should also be taken into consideration that the washing solution prepared with Niaouli may not have been used as recommended by some patients due to the diagnosis of hemiplegia and presence of spasticity in 54,4% of the cases, albeit at different stages.

The most important limitation of this study is the retrospective design. The lack of a control group and the number of cases are among other limitations. In addition, since the patient group was diagnosed with hemiplegia, they may not have applied the washing solution properly due to mental perception and physical activity limitations. However, the results of this study showed the statistically significant effect of the use of Niaouli oil on UTIs in stroke patients, which has not been previously investigated in the literature.

CONCLUSION

This study shows that the use of niaouli aromatherapeutic oil is beneficial in urinary tract infection in hemiplegic patients.

TTO is considered a safe antiseptic due to its natural origin and has started to be included in many pharmaceutical and cosmetic preparations in recent years. Scientific research on this oil has shown that it is effective in a wide range of microorganisms at very low concentrations. In vitro studies have proven that TTO can be used as an effective topical antimicrobial agent, and there is ongoing research to determine the possible mechanisms of action.

Although there are many in vitro studies on TTO, promising results have been obtained only from a limited number of case reports and clinical studies. Despite the proven efficacy of this oil, case studies should reach a sufficient number, and control groups should be included in clinical studies. In the treatment of UTIs, one of the serious complications in stroke patients, resistance to antibiotics has become a global problem. Our results suggest that tea tree (Niaouli) oil can be used as an alternative to medical treatment in patients with stroke that develop UTIs. It is important to increase the number of controlled clinical trials to ensure the safer use of this promising essential oil.

ETHICAL DECLARATIONS

Ethics Committee Approval: This study was carried out with the permission of Adana City Hospital Clinical Researches Ethics Committee (Date: 08.09.2022, Decision No: 2136).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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