ORIGINAL RESEARCH

Effects of Mineral and Almond Oil Administration on Transepidermal Water Loss and Skin Acidity in Chronic Renal Failure Patients Undergoing Hemodialysis

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ABSTRACT

Introduction: Patients undergoing hemodialysis experience decreased moisture content in the dermis due to fluid transfer during the dialysis process, causing xerosis, pruritus, and damage to the skin barrier. Almond oil and mineral oil are well-known moisturizers used in skin care products.
Objectives: To compare the effect of almond oil with mineral oil on transepidermal water loss (TEWL) and skin acidity in hemodialyzed chronic renal failure (CRF) patients.
Methods: An experimental study was conducted on patients with chronic renal failure (CRF) undergoing hemodialysis at Dr. Moewardi Hospital in Indonesia. The study involved applying mineral and almond oils twice daily on the right and left forearms for four weeks. We measured TEWL and pH levels before and after the treatment.
Results: There is a significant difference in TEWL between before and after mineral oil application (p=0.036), but not in the almond oil arm (p=0.394). Subsequently, the change of TEWL value significantly differed between mineral oil and almond oil (p=0.043). However, the effects of mineral oil and almond oil on pH were insignificant (p=0.574 and 0.268, respectively).
Conclusion: After undergoing hemodialysis, CRF patients experienced a statistically significant reduction in transepidermal water loss (TEWL) when using mineral oil compared to both baseline and almond oil.

INTRODUCTION

The epidermis is a layer of skin that protects the body from the external environment as a semipermeable membrane and maintains body moisture.[1] Subsequently, transepidermal water loss (TEWL) is the amount of water lost passively from the stratum corneum to the external environment and is usually estimated in humans at around 300-400 mL/day.[2,3] Increased TEWL is associated with skin barrier dysfunction, which is characterised by abnormal desquamation that leads to clumping of corneocytes, which presents visibly as scaling and flaking; loss of elasticity and increased rigidity, which leads to micro fissuring and macro fissuring; and epidermal proliferation.[2]

The degree of acidity of the skin plays a role in the chemical barrier function of the skin.[4] The stratum corneum is acidic with pH in the

range of 4.-5.8. This acidity inhibits the growth of pathogenic bacteria. The degree of acidity affects skin barrier function, lipid synthesis and aggregation, differentiation, and desquamation of the epidermis.[5] An increase in skin pH is caused by reduced fat metabolism, impaired lipid layer integrity, and increased protease enzyme activity. This can cause disruption of homeostasis, stratum corneum cohesion, and antimicrobial activity, thereby disrupting skin barrier function.[4,5]

In patients with chronic renal failure (CRF), there is damage to the skin barrier function, which causes clinical manifestations in the skin in the form of xerosis and pruritus.[6] Xerosis is caused by a decreased water content in the stratum corneum, impaired sebum production due to atrophy of the sebaceous glands, and a decrease in the water content of the dermis layer due to fluid movement during the dialysis process.[7] Pruritus in CRF patients is caused by xerosis, toxin deposition, immune system dysregulation, as well as release of histamine and opioids.[8] This leads to the need for therapies to treat skin conditions in CRF patients. Almond and mineral oils are moisturizers that have been widely used in various skin conditions. Almond and mineral oils also have been shown to be effective and safe as moisturizers for dry skin and dermatitis.[9,10] However, its use as a therapy for skin conditions in CRF patients has rarely been studied before. This study aims to determine the effectiveness of administering almond and mineral oil on TEWL and skin pH in CRF patients undergoing hemodialysis.

METHODS

Study Design

This experimental study was carried out at the hemodialysis room of Dr. Moewardi General Hospital, Surakarta, Indonesia, from February to March 2023. The study was conducted on subjects of CRF patients undergoing hemodialysis. This research has undergone an ethical review and received ethical clearance from the Health Research Ethics Committee of Dr. Moewardi General Hospital (approval # 132/I/HREC/2023).

Participants

This study used a total sample approach. Inclusion criteria include CRF patients undergoing hemodialysis aged 20-80 years willing to participate in the research by filling out informed consent. Meanwhile, the exclusion criteria were patients with active inflammatory skin lesions on both forearms. Individuals with health conditions that could interfere with TEWL and skin pH assessment, including those with severe skin allergies, infections, or other dermatological conditions wereexcluded. Subsequently, pregnant and lactating individuals and individuals with significant cognitive impairments were excluded from the study.

Treatment Procedure

On the same subject, mineral oil, Johnson's Baby Oil® (Johnson & Johnson, United States), was applied to the volar aspect of the right forearm and almond oil, Darjeeling Almond Oil® (BPOM: TR236026321), to the volar of the left forearm twice a day after bathing for four weeks. Subjects were asked to report any side effects during treatment, such as itching, irritation, redness, and burning. All research subjects were also asked to stop using other brands of soap and moisturizer two weeks before treatment and were given soap of the same brand.

Data Collection

TEWL and pH values were measured before and after treatment at the end of the fourth week. The first step was to ask the subject to rest for 10-15 minutes before measurement, then the TEWL value was measured with TEWAMETER® TM-300 (Courage-Khazaka, Germany) and skin pH with PH100: ExStik® pH Meter (ExTech, United States) in a room temperature of 20-22 °C. TEWL and pH measurements were carried out on the volar forearm.

Statistical Analysis

Data is presented as a mean (standard deviation) and frequency (percentage). The normality test for TEWL and pH measurements was carried out using the Shapiro-Wilk test, and the homogeneity test was carried out using Levene's test. The effectiveness of almond and mineral oil on TEWL and skin pH was measured using the independent T-test, paired T-test, and Wilcoxon test. A two-sided $P < 0.05$ was the threshold of statistical significance. Statistical analyses were carried out with IBM SPSS 24.0 statistical software (SPSS Inc., United States).

RESULTS

Fifteen patients were enrolled in this study, seven males (46.7%) and eight females (53.3%) aged 45.53 ± 13.09 years old. The results of this study show that there was a statistically significant difference in TEWL values before and after administration of mineral oil (p=0.036), with decreased TEWL values after treatment (10.69±2.70) compared to before treatment (11.23±2 .24). Meanwhile, there was no difference in TEWL values before and after administering almond oil (p=0.394) (**Table 1**). There was no difference in pH values before and after the administration of mineral oil and almond oil (**Table 2**).

We then compared the changes in TEWL and pH values between almond and mineral oil to further determine the difference in effectiveness between the two. There was a significant difference in changes of TEWL values when administering mineral oil compared to almond oil (p=0.043; -0.54±0.79 vs 0.24±1.19). Meanwhile, there was no significant difference in changes in pH values when administering mineral oil and almond oil (p=0.756; -0.14±0.92 vs -0.24±80) (**Table 3**).

DISCUSSION

Skin is the main protective organ, a physical barrier that covers the entire body surface against the external environment, controls fluid loss, and maintains body balance.[11] The epidermis of the skin is the outermost epithelial tissue that forms an effective barrier against external stimuli, as a semipermeable membrane, and helps maintain moisture on the skin.[12]

TEWL and skin pH measurements are some of the tests used to non-invasively evaluate biophysical parameters and reflect the presenceof skin barrier damage. An increase in TEWL plays a role as a parameter of skin barrier dysfunction, while a decrease in TEWL indicates a good skin barrier. An increase in TEWL can reflect the level of skin dryness and cause manifestations of dry skin or xerosis, as well as an itchy sensation that will damage the skin barrier function. Factors that influence TEWL are the individual's anatomical location. TEWL on the palms and soles, axillae, forehead, forearms, and calves are higher due to low lipid content.[13] The pH condition of the skin reflects the regulatory role of enzyme activity, especially in

Table 1. TEWL before and after administration of mineral oil and almond oil

Intervention	Pre-	Post-	P-value
Mineral oil (n=15)	11,23±2,24	10,69±2,70	0,036[a*]
Almond oil (n=15)	10,99±3,08	11,23±2,57	0,394[a]
Wilcoxon test, *statistically significant			

Table 2. pH before and after administration of mineral oil and almond oil

Intervention	Pre-	Post-	P-value
Mineral oil (n=15)	4,98±0,79	4,84±0,29	0,281[a]
Almond oil (n=15)	5,15±0,65	4,91±0,38	0,598[a]
Wilcoxon test			

Table 3. Changes in TEWL and pH after administering mineral oil and almond oil

Intervention	Mineral oil (n=15)	Almond oil (n=15)	P-value
TEWL	-0,54±0,79	0,24±1,19	0,043[a*]
pH	-0,14±0,92	-0,24±0,80	0,756[a]
independent t-test, *statistically significant			

keratinization and skin barrier regeneration. Skin pH is influenced by anatomical locations such as the forearms and forehead, which have different skin pH levels.[4] This study conducted TEWL and pH examinations on the volar forearms and research subjects. They were asked to rest for 10-15 minutes before measurement so that the measurement conditions for all subjects were on the same condition.

The skin of CRF patients experiences atrophy of the epidermis, sebaceous glands, tubules, and secretory ducts of the eccrine glands and hyperkeratosis. Sweat secretion is reduced, so skin moisture decreases, which affects the elimination of electrolytes, urea, amino acids, and lipids. The level of glycerol, a component of natural moisturizing factors, also decreased.[14] In this study, CRF patients who underwent hemodialysis were study subjects with various skin manifestations, including pruritus and xerosis.

Moisturizers are essential in skincare when the skin barrier is compromised.[14,15] Moisturizers play a role in increasing the water content in the stratum corneum, maintaining normal skin pH, maintaining the lipid layer as a connector for corneocytes, and maintaining moisture in the intercellular space. Moisturizers can also further improve the skin barrier due to their antiinflammatory, antimitotic, antipruritus, photoprotective, antimicrobial, and wound healing properties.[15]

Mineral oil is a synthetic oil that has occlusive properties create a barrier, improving barrier

function by reducing water loss in the stratum corneum. Mineral oil molecularly forms a hydrophobic barrier on the skin's surface by reducing the movement of water molecules across the stratum corneum, thereby reducing TEWL.[16] Almond oil is produced from almond tree seed (*Prunus dulcis*). It function as moisturizers, revitalizers, protectors, and skin smoothness. It'sbeen proven to increase water levels in the epidermis.[17]

Rawlings and Lombard in South Africa reported that mineral oil could lower the skin's pH by forming a physical barrier that prevents water loss from the skin, thereby lowering the skin's pH. Mineral oil can also increase skin permeability to water and other substances affecting skin pH.[18] Mineral oil applied twice daily for four weeks was shown to influence TEWL in hemodialysis patients by forming a healthy skin barrier.[19] In this study, the oil Minerals statistically significantly reduced TEWL after treatment compared to baseline TEWL.

Blaak *et al*. in Germany reported that almond oil has a positive effect on dry skin and TEWL. This effect is thanks to its fatty acid content, which is a major component of the skin barrier, thus relieving itchy and dry skin.. Almond oil contains high oleic acid as a carrier, facilitating the penetration of other active substances into the skin.[19] Santoro *et al*. in Germany and France reported that almond oil was proven to increase stratum corneum hydration in the skin of premature neonates with an imbalance in stratum corneum hydration.[20] In this study, the differences in TEWL and skin pH values before and after almond oil administration were not statistically significant due to the small sample size, variability in skin pH measurements, and short duration of intervention, so longer or more frequent applications were needed to produce significant changes.

Jacqueline *et al*. in Manila, compared mineral oil with virgin coconut oil for the therapy of xerosis uremicum in CKD patients undergoing hemodialysis, and showed that both oils were valuable and safe for the treatment of xerosis uremicum, which was characterized by improved dry skin scores, increased skin hydration and increased quality of life score.[21] Another study by Singh and Vinayadev in Dubai reported that baby oil with one of the ingredients in the form of mineral oil effectively reduced pruritus scores in patients with pruritus uremicum who underwent hemodialysis compared to controls.[22] In this study, mineral oil has a significantly lower TEWL value than almond oil.

The study acknowledges several limitations that deserve consideration. First, the sample size was small, and the research was conducted at only a single center. The study's short treatment duration of four weeks and absence of a control group is another limitation of this study. Lastly, the subjective reporting of side effects by subjects introduces a potential response bias.

CONCLUSION

In conclusion, the study offers valuable insights into the effects of almond and mineral oils on TEWL and skin pH in CRF patients undergoing hemodialysis. Notably, mineral oil demonstrated a statistically significant decrease in TEWL values compared to baseline and almond oil. In contrast, no statistically significant difference was found in pH before and after the administration of mineral oil and almond oil. The reduction in TEWL with mineral oil suggests its potential benefit in managing

skin barrier function in CRF patients undergoing hemodialysis. This could have significant clinical implications, prompting healthcare practitioners to consider incorporating mineral oil into skincare regimens for these patients.

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