Measurement of transepidermal water loss (TEWL) in cats with experimental skin barrier dysfunction using a closed chamber system

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Background – A closed chamber evaporimeter is suitable for measuring transepidermal water loss (TEWL) in cats because of the compact device size, tolerance to sudden movement and short measuring time. TEWL is a representative parameter for skin barrier dysfunction, which is one of the clinical signs of atopic dermatitis in humans and dogs. Measurement of feline TEWL has been reported, but applicability of this parameter has not been validated.

Hypothesis/Objectives – The aims of this study were to determine if tape stripping is a valid experimental model in cats for studying TEWL and to determine if a closed chambered system is a suitable measurement tool for cats.

Animals – Ten clinically normal cats.

Methods – In order to evaluate variation of the measured values, TEWL was measured at the right and left side of the three clipped regions (axillae, lateral thigh and groin). Subsequently, TEWL was measured using sequential tape stripping of the stratum corneum as a model of acute barrier disruption.

Results – The variations between both sides of the three regions showed no significant difference. Sequential tape stripping was associated with increasing values for TEWL.

Conclusions and clinical importance – Feline TEWL was shown to reflect changes in the skin barrier in an experimental model using a closed chamber system and has the potential for evaluating skin barrier function in cats with skin diseases.

Introduction

Skin barrier dysfunction has been shown to be an initial event in the development of human atopic dermatitis (AD), and transepidermal water loss (TEWL) is a representative parameter for assessing skin barrier function. The measurement of TEWL has been validated for dogs. Neither the pathogenesis of feline AD nor the measurement of TEWL have not been elucidated precisely in cats.

Validating evaporimeter devices is a prerequisite for the measurement of TEWL. Currently there are two commercial systems: open chamber and closed chamber. The measurement of TEWL in cats has been measured with two devices: the Tewameter® (KOKO Kosmetikvertrieb; Köln, Germany) and the VapoMeter® (Delfin Technologies Ltd; Kuopio, Finland). The former device is an open chamber system which is a standard method used in humans (the European Contact Dermatitis Society and the European group on Efficacy Measurements of Cosmetics and Other topical products). The Tewameter® measures TEWL by calculating the water evaporation gradient developing from the skin surface to atmospheric humidity. Therefore, body-induced air flows near the chamber will influence this method when measuring different skin regions, which limits its clinical use in cats.

The VapoMeter® uses a chamber which is closed after touching the skin surface; it is saturated with water vapour from the stratum corneum (SC). A microsensor measures the increasing rate of relative humidity inside the chamber. This method is not influenced by ambient or body induced air flows around the chamber; it is less likely to be affected by movement, which is an important advantage when working with cats. In addition, it takes only 8 ~ 10 s versus 30 ~ 40 s to use, compared with the Tewameter®.

One study has questioned the reliability of the VapoMeter® in dogs due to inconsistent measurement on the right and left sides of the dogs’ trunks, even though measurements were taken at the same anatomical site. In addition, there was intradividual variation and inter-day variation at the same site. Previously, we have established a standardized measurement technique in...
cats for minimizing variations in TEWL readings, using a VapoMeter®. Based on this procedure, repeated measurement of TEWL at the same body location did not vary over time.

The study of TEWL is potentially important in understanding the pathogenesis of various skin diseases in cats. The goals if this study were to determine (i) if tape stripping causes similar changes in the SC as in other species and (ii) there are differences in TWEL at different anatomical sites in cats when tested using a closed chamber system.

Materials and methods

Experimental animals
The study was conducted on 10 clinically normal, Domestic short hair cats of both sexes (five spayed females and five castrated males), ranging in age from 11 months to 4 years (mean 2 years 1 month). Cats were housed in our animal facility. The animals were rested, on the day of testing, in the test room for 1 h at 24 ± 2°C with relative humidity 56 ± 4%, before the measurements were taken. Approval for this study was granted by our institutional animal care and use committee.

Anatomical sites and protocol
Three regions (axillae, lateral thigh and inguinal region) were used for comparison of variations between the right and left side at the same anatomical region (Figure 1). The inguinal region was chosen to artificially impair the SC with a tape stripping method. The test sites were shaved using an electric clipper with 0.3 mm blade (89 Super Taper, WAHL Co.; Tokyo, Japan). The clipper blade was held parallel to the skin surface so as not to damage the cornified layer when clipping the hair coat. The clipped sites were acclimatized for 30 min before measuring TEWL.

Sequential removal of the SC
Sequential tape stripping of the SC was performed in six cats as a model of acute barrier disruption. The test site was the inguinal region and 20 consecutive tape strippings were performed on exactly the same skin area. TEWL was measured at the stripped site before the first and after the 5th, 10th, 15th and 20th tape stripping.

Measuring equipment
TEWL was measured using a VapoMeter SWL4001TJ (Delfin Technologies Ltd), a portable, battery-operated, closed, unventilated chamber evaporimeter. Measurements were consecutively repeated five times after the tape stripping and at the three anatomical sites. For each site, the mean of the five measurements was used as a representative value.

Histology
In order to evaluate changes in the SC due to tape stripping, 4 mm skin biopsy specimens were obtained from the inguinal regions in three cats. The biopsy specimens were fixed in buffered 10% formalin, embedded in paraffin, sectioned at 4 μm and stained with haematoxylin and eosin.

Statistical analysis
Values are given as mean ± SD. Statistical analyses were conducted using one-way ANOVA analysis and verified by Tukey’s multiple comparison test. Comparisons were made among different layers at the inguinal region. Spearman’s rank correlation test was used for correlation analyses between tape strip numbers and TEWL. An unpaired T-test was used for a comparison between the body sides at the same body location. The significance level was set at P < 0.05. Statistical analyses were conducted using GraphPad Prism® 5.2 (GraphPad Inc.; San Diego, CA, USA).

Results
A comparison between the right and left side at the three regions (axillae, lateral thigh and inguinal region) was performed. In the axillae there was no significant difference between the right (8.04 ± 1.09 g/m²/h) and the left side (7.88 ± 1.29 g/m²/h). The lateral thigh regions had no significant difference between the right (6.36 ± 0.82 g/m²/h) and the left side (6.42 ± 1.39 g/m²/h). The inguinal region also showed no significant variation between the right (6.69 ± 2.99 g/m²/h) and the left side (6.25 ± 1.33 g/m²/h).

The histopathological findings showed that the SC was still present after the 10th tape strip (Figure 2). The cornified layers were difficult to find after the 15th tape stripping and absent after the 20th.

According to the sequential tape stripping of the SC, the TEWL value before tape stripping was 6.18 ± 1.9 g/m²/h in the inguinal region (Figure 3). It increased to 8.60 ± 3.23 g/m²/h at the 5th strip and to 14.13 ± 8.06 g/m²/h at the 10th strip. The value rose sharply at the 15th tape stripping (46.96 ± 58.82 g/m²/h) and subsequently increased at the 20th stripping (62.24 ± 60.74 g/m²/h). The TEWL values gradually increased with repeated tape strippings. There was a positive correlation between TEWL values and the tape number (Spearman’s rank correlation, P < 0.0001).

Discussion
In a previous study we validated the use of the VapoMeter® and developed a technique for obtaining
logical findings (Figure 2) which showed that the SC was tape stripping. This change was supported by the histopathological findings induced by sequential tape stripping of feline skin. The samples were taken before the first and after the 5th, 10th, 15th and 20th tape stripping.

In the present study, no site variation in cats was found, unlike the case in dogs. The results of the tape stripping demonstrated that the feline TEWL values had a positive correlation with the frequency of tape stripping. Mean TEWL and SD increased abruptly after the 15th tape stripping. This phenomenon has also been recognized in dogs and humans. The present study demonstrated that accurate measurements of TEWL in cats are possible and reliable. In addition, this study demonstrated that tape stripping is potentially a useful experimental technique for investigating barrier function changes in cats.

In conclusion, the VapoMeter® is a reliable device to measure TEWL in cats. The present report confirmed that TEWL is potentially a useful parameter to evaluate the skin barrier function in cats in an experimental model.

References


Résumé

**Contexte** – Un évaporomètre à chambre fermée est adapté pour la mesure de la TEWL (transepidermal water loss) chez le chat grâce à la taille compacte de l’appareil, à la tolérance aux mouvements brusques et au courts temps de mesure. La TEWL est un paramètre représentatif pour les anomalies de barrière cutanée qui est un des signes cliniques de la dermatite atopique de l’homme et du chien. La mesure de la TEWL feline a été rapportée mais l’appropriabilité de ce paramètre n’a pas été validée.

**Hypothèses/Objectifs** – Les buts de cette étude étaient de déterminer si le «tape stripping» était un modèle expérimental valable chez le chat pour l’étude de la TEWL et de déterminer si un système en chambre fermée est un outil de mesure adapté au chat.
Sujets – Dix chats cliniquement sains.

Méthodes – Afin d’évaluer la variation des valeurs mesurées, la TEWL a été mesurée sur les régions droites et gauches de trois zones tondues (plis axillaires, cuisse latérale et pli inguinale). Ainsi la TEWL a été mesurée après tape stripping répété du stratum corneum comme modèle de rupture de barrière cutanée aiguë.

Résultats – Les variations entre les deux cotés des trois régions n’ont pas montré de différence significative. Les tapes stripings séquentiels étaient associés à des valeurs augmentées de TEWL.

Conclusions et importance clinique – Il a été montré que la TEWL féline reflète les changements dans la barrière cutanée dans un modèle expérimental à l’aide d’un système en chambre fermée et a le potentiel pour évaluer la fonction barrière cutanée chez les chats atteints de dermatoses.

Resumen

Introducción – un evaporímetro de cámara cerrada es adecuado para medir la pérdida de agua transepidermática (TEWL) en gatos debido al pequeño tamaño del dispositivo compacto, la tolerancia al movimiento repentino y el tiempo de medición corto. TEWL es un parámetro representativo de disfunción de la barrera de la piel, que es uno de los signos clínicos de la dermatitis atópica en los seres humanos y perros. La medición TEWL en gatos ha sido publicada, pero la aplicabilidad de este parámetro no se ha validado.

Hipótesis / Objetivos – Los objetivos de este estudio fueron determinar si el daño epitelial con cintas adhesivas es un modelo experimental válido en gatos para el estudio de TEWL y determinar si un sistema de cámara cerrada es una herramienta de medición adecuada para gatos.

Animales – Diez gatos clínicamente normales.

Métodos – Con el fin de evaluar la variación de los valores medidos, TEWL se midió en los lados derecho e izquierdo de tres regiones rapadas (axilas, cara lateral del muslo y la ingle). Posteriormente, TEWL se midió usando tratamiento con cintas adhesivas secuenciales del estrato córneo como un modelo agudo de alteración de la barrera de la piel.

Resultados – Las variaciones entre los dos lados de las tres regiones no mostraron diferencias significativas. El daño con cintas adhesivas secuenciales se asoció con aumento de los valores de TEWL.

Conclusiones e importancia clínica – La TEWL en gatos refleja los cambios en la barrera de la piel en un modelo experimental utilizando un sistema de cámara cerrada y tiene el potencial para evaluar la función de la piel en los gatos con enfermedades de la piel.

Zusammenfassung


Tiere – Zehn klinisch normale Katzen.

Methoden – Um eine Variation der gemessenen Werte zu evaluieren, wurde die TEWL an der rechten und linken Seite der drei geschorenen Stellen (Achseln, laterale Flanken und Ingualregion) gemessen. In der Folge wurde die TEWL mittels sequentiellen Strippen des Stratum corneum durch Klebestreifen als ein Modell der akuten Barrierestörung gemessen.


要約

背景 – 閉鎖チャンバー型蒸発計 (Closed chamber evaporimeter) は、機械が小型であること、動物の急速な動きにも対応できること、短時間で測定できることにより、竜の環境水分喪失量（transepidermal water loss: TEWL）を測定するのに適している。TEWLは、入院犬のアトピー性皮膚炎の臨床所見の一つである皮膚バリアの機能異常を示す指標となる。これまで、竜のTEWLを測定した報告はあるが、その適用性についてはまだ検証されていない。

仮説/目的 – 本研究の目的は、竜の実験モデルを用いて、テープによる剥離法 (tape stripping) およびclosed chamberシステムの有用性および適用性を評価することである。

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为了三个测试，左、右两侧的毛环部(腋下、大腿外侧、臀部)对TEWL做了测定，其后急性皮肤损伤模型作为角质层的tape stripping是行了的皮膚的TEWL也测定。

结果 — 左右3组的测定部位间 TEWL值有意义的差是认为了，Tape strippingを繰り返した皮膚で

結論および臨床的な重要性 — Closed chamberシステムを用いた実験モデルにおいて、猫のTEWLは皮膚バリアの

変化を反映している。今後、猫の皮膚疾患における皮膚バリア機能の評価に応用できる可能性が示唆された。

Resumo

Contexto — A câmara evaporimetrica é apropriada para a mensuração da perda da água transepidérmica (TEWL) em felinos devido ao tamanho compacto do aparelho, tolerância a movimentos bruscos e tempo de mensuração curto. TEWL é um parâmetro representativo para a disfunção da barreira cutânea, que é um dos sinais clínicos de dermatite atópica em humanos e cães. A mensuração da TEWL em felinos já foi reportada, mas a aplicabilidade desde parâmetro não foi validada.

Hipóteses/Objetivos — Este estudo tem como objetivo determinar se o método de decalque por fita adesiva é um modelo experimental válido para felinos, com o intuito de se avaliar a TEWL e determinar se o sistema de câmara fechada é uma ferramenta adequada para gatos.

Animais — Dez gatos clinicamente saudáveis.

Métodos — Para se avaliar a variação dos valores mensurados, TEWL foi medida nos lados esquerdo e direito de três regiões tosquidadas (axilas, lateral da coxa e inguinal). Subsequentemente, a TEWL foi medida através de decalque do estrato córneo por fita adesiva como um modelo experimental de ruptura aguda da barreira cutânea.

Resultados — As variações entre os dois lados das três regiões não demonstrou nenhuma diferença significativa. O decalque por fita adesiva sequencial foi associado com valores crescentes de TEWL.

Conclusões e importância clínica — Demonstrou-se que a TEWL felina reflete as mudanças na barreira cutânea, em um modelo experimental utilizando um sistema de câmara fechada, e, potencialmente, pode ser utilizada para avaliar a função da barreira cutânea em felinos.