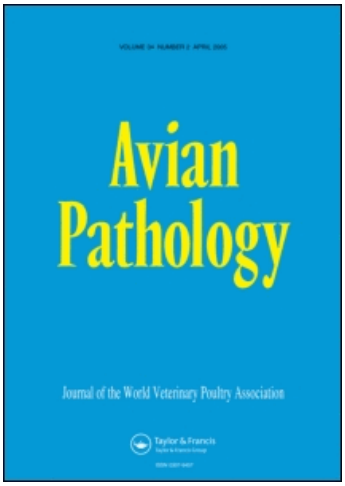

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Plasma urea, creatinine and uric acid concentrations in relation to feeding in peregrine falcons (*Falco peregrinus*)

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SUMMARY

Significant post-prandial increases in plasma uric acid and plasma urea concentrations were observed in peregrine falcons. Post-prandial uric acid concentrations were similar to those in birds suffering from hyperuricaemia and gout and were well above the theoretical limit of solubility of sodium urate in plasma. It is not clear why under normal circumstances no urate deposits occur in peregrine falcons (and probably other raptorial birds), which show hyperuricaemia for at least 12 h after ingesting a natural meal.

It is important to evaluate renal function in peregrine falcons (and perhaps other birds) after a 24-h fast to avoid misinterpretation due to physiological food-induced elevated concentrations of nonprotein nitrogen substances.

INTRODUCTION

Plasma uric acid concentration (PUAC) has traditionally been considered an appropriate variable to evaluate renal function in birds (Lewandowski *et al.*, 1986), but it was shown that this variable does not rise significantly above reference values in dehydrated pigeons (Lumeij, 1987). Hyperuricaemia has been reported in association with articular and visceral gout in birds (Gratzl & Koehler, 1968; Siller, 1959; Stonebrink, 1947). Urea, despite its very low concentrations in avian plasma, has been demonstrated to be useful for diagnosing prerenal causes of renal failure in birds, such as dehydration (Lumeij, 1987). Plasma creatinine concentrations also show significant increases in dehydrated pigeons (Lumeij, 1987).

In a clinical setting it is important for the clinician to differentiate between renal and extrarenal causes of elevated plasma concentrations of nonprotein nitrogen waste products (NPNWP).

Long term feeding of protein rich diets to granivorous birds can induce hyperuricaemia and gout (Siller, 1959). Although hyperuricaemia and gout have also been reported in raptors, no information could be traced with regard to physiological variations in plasma concentations of NPNWP in carnivorous birds.

The present study was designed to investigate the physiological variations in plasma

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urea, creatinine and uric acid concentrations in carnivorous birds after ingestion of a protein rich meal, so as to enable the clinician to differentiate between physiological and pathological causes of elevated NPNWP concentrations. Peregrine falcons (*Falco peregrinus*) were chosen as experimental animals, since these extremely valuable birds are used worldwide for falconry purposes and evaluation of renal function is commonly indicated in the course of diagnosing or treating various diseases.

MATERIALS AND METHODS

For this study healthy adult female peregrine falcons from the Dubai Falcon Hospital were used. The birds had been trained for falconry and were handled by experienced falconers by standard methods (Cooper, 1978). Blood collection and analysis were performed in Dubai in November 1989.

Post-prandial plasma concentrations of urea, creatinine and uric acid of five falcons were compared with values found after a period of food deprivation for 42 h. Blood was collected from the jugular vein using heparinised vacutainers before and at 3, 8, 15 and 24 h after feeding the birds a complete, skinned quail (*Coturnix coturnix*), which was ingested within 30 min by all birds.

A Dupont Dimension® (Dupont, Medical Products Department, Wilmington, Delaware 19898, USA) automated clinical chemistry system was used for determination of plasma urea nitrogen, creatinine and uric acid. Analyses were performed at 37°C using a bichromate rate (urea and creatinine) and bichromatic endpoint (uric acid) measurement.

For urea nitrogen an urease/glutamate dehydrogenase coupled enzymatic technique according to Talke & Schubert (1965) was employed. The creatinine method consisted of a modification of the kinetic Jaffé reaction reported by Larsen (1972). The uric acid method was a modification of the uricase method first reported by Bulgar & Johns (1941), and later modified by Kalckan (1947).

Differences between plasma concentrations of the various variables were tested for significance using the Kruskal-Wallis test, whereby significance was assumed when $P<0.05$.

RESULTS

Significant post-prandial elevations of plasma uric acid and urea concentrations were observed in the peregrine falcons. Peak concentrations of plasmic uric acid (up to 1881 μmol/l) were observed between 3 and 8 h post-prandially, while plasma urea concentrations peaked at 8 h post-prandially (up to 3.2 mmol/l). Creatinine concentrations did not show significant elevations from baseline values (Figure 1). Although all the birds ingested the quail within 30 min, remnants of the quail could be palpated in the crop until 15 h after ingestion in three out of five birds.

DISCUSSION

This study has clearly demonstrated that significant post-prandial increases of plasma uric acid and urea concentrations occur in peregrine falcons for up to 15 h. The frequent handling of the peregrine falcons for blood sampling, however, might have slowed down the passage of blood from the crop through the gastrointestinal tract. Post-prandial PUACs found in this study were of the same order of magnitude as those reported in granivorous birds suffering from hyperuricaemia and gout (Gratzl & Koehler, 1968; Lin

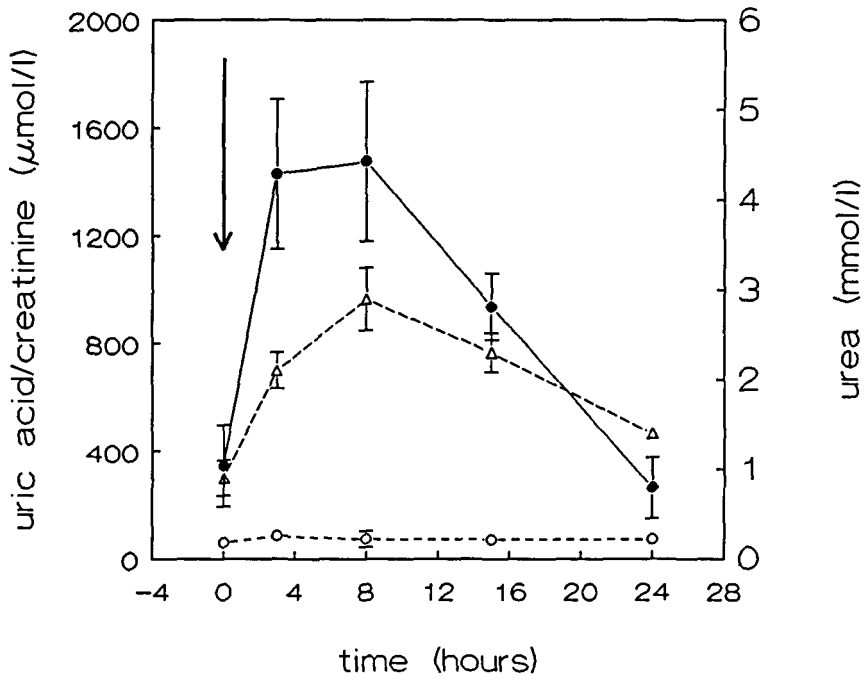

Figure 1. *Fasting and post-prandial non-protein nitrogen substances in plasma of peregrine falcons,* Falco peregrinus *(mean ± SD)* ● = *[uric acid] (μmol/l);* △ = *[urea] (mmol/l);* ○ = *[creatinine] (μmol/l);* ↓ = *feeding quail.*

et al., 1976; Siller, 1959). Hyperuricaemia is hereby defined as any plasma uric acid concentration higher than the calculated limit of solubility of sodium urate in plasma. An ordinary aqueous solution at 37°C, with a sodium concentration equal to that of normal human plasma, is saturated when the urate concentration reaches 383 to 407 μmol/l. It is generally accepted that the upper limit for absolute solubility of urate in human plasma is 420 μmol/l (Chonko & Grantham, 1981). Urate solubility increases with higher sodium concentrations and higher temperatures. When the higher body temperature of birds (up to 43°C) is taken into account, the theoretical limit of solubility of sodium urate in avian plasma would be about 600 μmol/l. Post-prandial values in the present study were well above this value. However, there is no evidence that urate crystals are deposited in the tissues of peregrine falcons under normal circumstances. It seems therefore that other substances in plasma enhance urate solubility in (raptorial) birds. Alvsaker (1966) has demonstrated reversible interactions between urate and four components of human plasma; the two most important were albumin and an alpha-globulin that appeared to be absent from the plasma of some people with gout. Kovarsky *et al.* (1976), however, concluded that in man no more than 4 to 5% of urate is bound to plasma proteins *in vivo*.

Although hyperuricaemia can result in urate precipitation in joints and in visceral organs or other extravisceral sites (Cooper, 1978), precipitations of uric acid in blood, with marked increases of uric acid concentrations, have not been observed. The exact mechanism of deposition or the predilection for certain sites is unknown (Knox, 1980). Five cases of visceral gout are documented at the Dubai Falcon Hospital. From two of these cases PUAC were established *ante mortem* and both cases showed hyperuricaemia: a female saker falcon (*Falco cherrug*) had a PUAC of 2450 μmol/l and a female immature

peregrine falcon had a PUAC of 1527 μmol/l. Although all cases were grossly obvious, displaying a white frosted appearance to visceral surfaces (most notably the pericardium), the latter case was additionally confirmed by the murexide test. It is not clear why under physiological conditions no urate deposits occur in peregrine falcons (and probably other raptorial birds), which show hyperuricaemia for at least 12 h after ingesting a natural meal.

It is concluded that in a clinical setting it is important to evaluate renal function in peregrine falcons (and perhaps other birds) after a 24-h fast to avoid misinterpretation due to physiological food-induced elevated plasma concentrations of NPNWP, especially uric acid and urea.

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RESUME

Concentrations plasmatiques de l'urée, la créatinine et l'acide urique en relation avec l'alimentation de faucons pellerins (*Falco peregrinus*)

Une augmentation significative post-prandiale des concentrations plasmatiques d'acide urique et d'urée a été observée chez le faucon pellerin. La concentration d'acide urique post-prandiale a été similaire à celle d'oiseaux souffrant d'hyperuricémie et de goutte, et valeurs étant au dessus de la limite théorique de solubilité de l'urate de sodium dans le plasma. La raison pour laquelle, dans des conditions normales, aucun dépôt d'urate n'a été observé chez les faucons pellerins (et probablement d'autres oiseaux rapaces) n'est pas claire, alors que l'hyperuricémie dure au moins 12 heures après ingestion d'un repas normal.

Il est important d'évaluer la fonction rénale du faucon pellerin (et peut-être d'autres oiseaux) après 24 heures de jeûne afin d'éviter de fausses interprétations dues à des concentrations élevées de substances nitrogènes non protéiques dues physiologiquement à la nourriture.

ZUSAMMENFASSUNG

Harnstoff-, Kreatinin- und Harnsäurekonzentrationen im Plasma von Wanderfalken (*Falco peregrinus*) in Relation zur Nahrungsaufnahme

Bei Wanderfalken wurden beträchtliche postprandiale Erhöhungen der Harnsäure- und Harnstoffknozentrationen im Plasma festgestellt. Die postprandialen Harnsäurekonzentrationen waren ähnlich wie die bei Vögeln, die an Urikämie und Gicht leiden und lagen deutlich über der theoretischen Löslichkeitsgrenze von Natriumurat im Plasma. Es ist unklar, warum unter normalen Umständen bei Wanderfalken (und vermutlich anderen Raubvögeln), die nach Aufnahme einer natürlichen Mahlzeit mindestens 12 Stunden lang eine Hyperurikämie haben, keine Uratablagerungen vorkommen.

Es ist wichtig, daß man die Nierenfunktion von Wanderfalken (und vielleicht anderen Vögeln) erst nach 24stuñdigem Fasten beurteilt, um Fehlinterpretationen aufgrund der nahrungsbedingt physiologisch erhöhten Konzentrationen von Stickstoffsubstanzen, die keine Proteine sind, zu vermeiden.

RESUMEN

Niveles de urea, creatinina y acido urico plasmaticos en relacion con la alimentacion en halcones peregrinos (*Falco peregrinus*)

Se observaron incrementos significativos postpandriales en los niveles de ácido úrico y urea plasmáticos de halcones peregrinos. Las concentraciones postpandriales de ácido úrico fueron similares a las encontradas en aves con hiperuricemia y gota, encontrándose por encima del límite teórico de solubilidad del urato sódico en el plasma. No está claro por qué en circunstacias normales no se producen depósitos de uratos en halcones peregrinos (y probablemente en otras repaces) que muestran una hiperuricemia durante al menos 12 horas después de ingerir una alimentación natural.

Es importante evaluar la función renal en los halcones peregrinos (y quizás en otras aves) tras un perído de ayuno de 24 horas para evitar interpretaciones erróneas debidas al incremento fisiológico de sustancias nitrogenadas no proteícas inducido por la alimentación.