# Ultrasonography of the parathyroid glands as an aid in differentiation of acute and chronic renal failure in dogs

Claudia E. Reusch, DVM, PhD; Kamil Tomsa, DVM; Cindy Zimmer, DVM; Angelika Hoerauf, DVM; Claudia Nett, DVM; Stefan Unterer, DVM; Tony M. Glaus, DVM, DACVIM; Elisabeth Schlittner; Andreas Pospischil, DVM, PhD

**Objective**—To evaluate whether determination of parathyroid gland size by use of ultrasonography is helpful in differentiating acute renal failure (ARF) from chronic renal failure (CRF) in dogs.

**Design**—Prospective study.

**Animals**—20 dogs with renal failure in which serum creatinine concentration was at least 5 times the upper reference limit. Seven dogs had ARF, and 13 dogs had CRF. Twenty-three healthy dogs were used as controls.

**Procedure**—Dogs were positioned in dorsal recumbency for ultrasonographic examination of the ventral portion of the neck, A 10-MHz linear-array high-resolution transducer was used. The size of the parathyroid gland was determined by measuring the maximal length of the gland on the screen when it was imaged in longitudinal section. For comparison among groups, the longest linear dimension of any of the parathyroid glands of each dog was used.

**Results**—Size of the parathyroid glands in the control dogs varied from 2.0 to 4.6 mm (median, 3.3 mm). In the dogs with ARF, gland size ranged from 2.4 to 4.0 mm (median, 2.7), which was not significantly different from controls. In dogs with CRF, the glands were more distinctly demarcated from the surrounding thyroid tissue, than those of controls and dogs with ARF. Sizes ranged from 3.9 to 8.1 mm (median, 5.7 mm), which was significantly larger, compared with controls and dogs with ARF.

**Conclusions and Clinical Relevance**—In dogs with severe azotemia, ultrasonographic examination of the parathyroid glands was helpful in differentiating ARF from CRF. Size of the parathyroid glands appeared to be related to body weight. (*J Am Vet Med Assoc* 2000;217:1849–1852)

In dogs, differentiation of **acute renal failure (ARF)** from **chronic renal failure (CRF)** is imperative for therapeutic and prognostic reasons. Acute renal failure is potentially reversible and necessitates aggressive treatment. In contrast, CRF is irreversible and usually has a progressive course. History and results of physical examination and laboratory testing may help one determine the type of renal failure present. Long-term polydipsia and polyuria, poor body condition, and nonregenerative anemia indicate CRF. The sudden onset of listlessness, anorexia and vomiting, normal or elevated Hct, but good body condition indicate ARF. Additional diagnostic aids include assessment of kidney size, serum potassium concentration, urine sediment, and degree of metabolic acidosis. Unfortunately, these variables are not always reliable and may be misleading. Polydipsia and polyuria in a dog with CRF may be overlooked by the owner, and the disease may only be noticed when symptoms such as anorexia and vomiting develop. Dogs with ARF may be anemic because of gastrointestinal hemorrhage or decreased erythrocyte life span. Differentiation can be challenging in dogs with CRF that have acute deterioration of their condition called acute-on-chronic-renal-failure.[1,2]

A complication of CRF is the development of secondary hyperparathyroidism, which is the result of factors such as phosphorus retention, hypocalcemia, calcitriol deficiency, and **parathyroid hormone (PTH)**-resistance of bone.[3] Dogs with CRF have hyperplastic enlargement of the parathyroid glands because of increased production of parathyroid hormone.[4]

Wisner et al[5] described results of ultrasonographic examination of the parathyroid glands in dogs. In addition, there have been a number of reports on parathyroid gland size in dogs with hypercalcemia caused by various diseases.[6-8]

The purpose of the study reported here was to investigate whether determination of parathyroid gland size via ultrasonography is useful in differentiating ARF and CRF in dogs. The size of the parathyroid glands of dogs with ARF and CRF was compared with that of healthy dogs of various weights.

From the Clinic for Small Animal Internal Medicine (Reusch, Tomsa, Zimmer, Hoerauf, Nett, Unterer, Glaus, Schlittner) and the Institute of Veterinary Pathology (Pospischil), Faculty of Veterinary Medicine, University of Zurich, Winterthurerstrasse 260, 8057 Zurich, Switzerland.

## Materials and Methods

**Control dogs**—The parathyroid glands of 23 healthy dogs were examined and measured by use of ultrasonography. Dogs ranged in age from 1 to 11 years (median, 4 years) and weighed 6.5 to 47.0 kg (14.3 to 103.4 lb; median, 19 kg [41.8 lb]). There were 10 sexually intact males, 1 castrated male, 8 sexually intact females, and 4 spayed females; 17 breeds were represented, and 1 was a mixed breed. Dogs were assigned to 1 of 4 groups on the basis of body weight: < 10 kg (22 lb; n = 5), 10 to 19 kg (22 to 41.8 lb; 7), 20 to 29 kg (44 to 63.8 lb; 6), and > 29 kg (63.8 lb; 5). In all control dogs, serum concentrations of urea nitrogen, creatinine, sodium, potassium, calcium, phosphorus, and PTH were within reference ranges.

**Dogs with renal failure**—Twenty dogs in which serum concentration of creatinine was at least 5 times the upper reference limit and the type of renal insufficiency could be clearly classified as acute or chronic were included in the study.

Seven dogs had ARF. They ranged in age from 1 to 9 years (median, 2 years) and weighed 7.3 to 34.0 kg (16.1 to 74.8 lb; median, 21.0 kg [46.2 lb]). There were 2 sexually intact males, 3 sexually intact females, 1 castrated male, and 1 spayed female. Breeds included Flat-Coated Retriever (n = 2), Yorkshire Terrier (1), Azawakh (1), Golden Retriever (1), Hovawart (1), and 1 mixed-breed dog. In 3 dogs that died during treatment, a diagnosis of ARF was made on the basis of results of histologic examination of the kidney. In 2 of these 3 dogs, results of histologic examination results of the kidney as well as high serum titers to *Leptospira* spp serovars supported a diagnosis of leptospirosis as the cause of ARF. In the other 4 dogs, a diagnosis of ARF was made on the basis of isosthenuria before treatment, severe azotemia that persisted after rehydration, and complete normalization of azotemia after long-term intensive treatment. In 3 of these dogs, serologic testing identified leptospirosis as the cause of ARF.

Thirteen dogs had CRF. They ranged in age from 2 to 17 years (median, 9 years) and weighed 6.9 to 41.7 kg (15.2 to 91.7 lb; median, 29.0 kg [63.8 lb]). There were 6 sexually intact males, 1 castrated male, 1 sexually intact female, and 5 spayed females. Breeds included mixed breed (n = 4), Boxer (2), Miniature Schnauzer (1), Spitz (1), Flat-Coated Retriever (1), Entlebucher Sennenhund (1), Bernese Mountain Dog (1), Briard (1), and Bordeaux Dane (1). In 5 dogs, the diagnosis of CRF was made on the basis of results of histologic examination of the kidney obtained at postmortem; in 1 dog, the diagnosis was made via results of kidney biopsy. In 3 other dogs, information regarding the chronic nature of the renal disease was provided by the referring veterinarians; these dogs had CRF for 2 months, 1 year, and 2 years, respectively. The 4 remaining dogs had long-term polydipsia and polyuria, and ultrasonographic examination revealed small irregular kidneys, loss of internal renal architecture, and an increase in the overall renal echogenicity.

**Ultrasonographic examination**—For ultrasonographic examination of the ventral neck region, each dog was positioned in dorsal recumbency. The head and neck were moderately stretched, and the point of the mandible and sternum were kept in a straight line. The region to be examined was shaved, and transducer gel was generously applied. A 10-MHz linear-array high-resolution transducer[a] was used for the examinations, which were always performed by the same person (CER). Sedation of the dogs was not necessary. To image each thyroid and parathyroid gland longitudinally, the transducer was placed immediately caudal to the larynx in the jugular groove and the carotid artery was identified, also longitudinally. From this position, the transducer was tipped slightly medially in the direction of the trachea until the thyroid gland was apparent. Rotation of the transducer by 90° allowed for imaging of the thyroid and parathyroid glands in cross-section. The size of the parathyroid gland was determined by measuring the maximal length of the gland on the screen when it was imaged in longitudinal section (**Fig 1**).

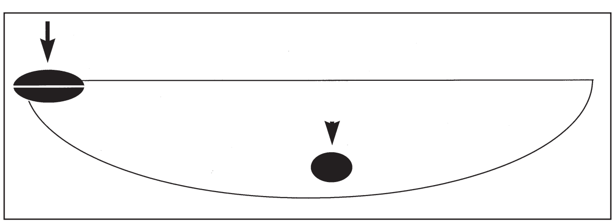

Figure 1—Schematic representation of a thyroid gland and cranial (arrow) and caudal (arrowhead) parathyroid glands in longitudinal section. The white line indicates the length of the cranial parathyroid gland, as measured by use of ultrasonography. For statistical analyses, the longest linear dimension of any 1 of the parathyroid glands of each dog was used.

**Statistical analyses—**Results were analyzed by use of nonparametric statistical methods.[b] Ranges and median values were recorded. For comparison of parathyroid gland size, the longest linear dimension, as determined via ultrasonography, was used according to data obtained by Wisner et al.[7] Comparison of data between all groups in the study was made by use of a Kruskal-Wallis 1-way ANOVA. If a significant difference between groups was detected, follow-up analysis to compare pairs of groups was made by use of the Mann-Whitney *U* test, incorporating the Bonferonni correction (multiplying each *P* value by 3). The relationship between various variables was studied by use of the Pearson correlation. Differences were considered significant when $P < 0.05$.

## Results

**Control dogs—**In 12 (52%), 7 (30%), and 4 (18%) of the control dogs, 4, 3, and 2 parathyroid glands were evident, respectively. Three of the latter 4 dogs weighed < 10 kg (22 lb) and the fourth weighed 13 kg (28.6 lb). In dogs that weighed > 30 kg (66 lb; n = 4), 4 parathyroid glands were always evident. All parathyroid glands were similar in appearance ultrasonographically. They were round to oval and were hypoechoic to anechoic, compared with surrounding tissue (**Fig 2**).

Size of the parathyroid glands varied from 2.0 to 4.6 mm (median, 3.3 mm). A high correlation ($r = 0.71$) was detected between body weight and size of parathyroid glands. For the various body weight categories, the largest parathyroid gland measured 3 mm in dogs < 10 kg (22 lb), 3.5 mm in dogs 10 to 19 kg (22 to 41.8 lb), 4 mm in dogs 20 to 29 kg (44 to 63.8 lb), and 4.6 mm in dogs > 30 kg (66 lb).

**Dogs with renal failure—**In dogs with ARF, BUN concentration ranged from 52 to 93 mmol/L (median, 70 mmol/L; reference range, 3.9 to 10.7 mmol/L), and serum creatinine concentration varied from 564 to 1,190 µmol/L (median, 731 µmol/L; reference range, 48 to 90 µmol/L). In dogs with CRF, BUN concentra-

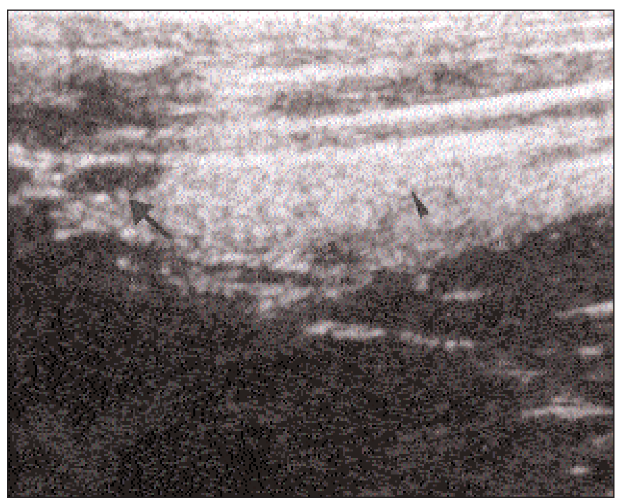

Figure 2—Ultrasonogram of the thyroid gland and cranial parathyroid gland (longitudinal section) of a healthy dog. Notice the thyroid gland (arrowhead), which has a homogeneous parenchyma and is more echogenic than the surrounding musculature. The parathyroid gland (arrow) is oval and oblong, appears hypoechogenic to anechogenic, and is well-demarcated from the surrounding thyroid tissue (size, 2.9 mm). At this plane, the caudal parathyroid glands are difficult to see.

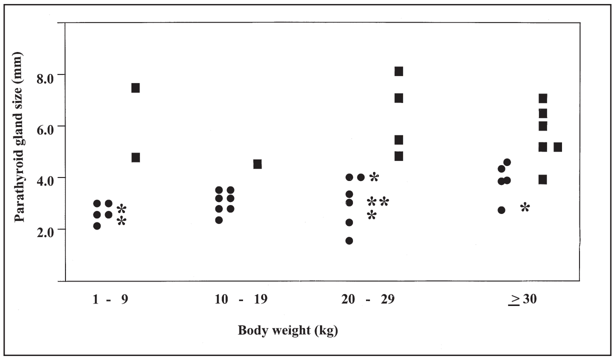


Figure 3—Parathyroid gland size in control dogs (•), dogs with acute renal failure (*), and dogs with chronic renal failure (■) grouped according to body weight.

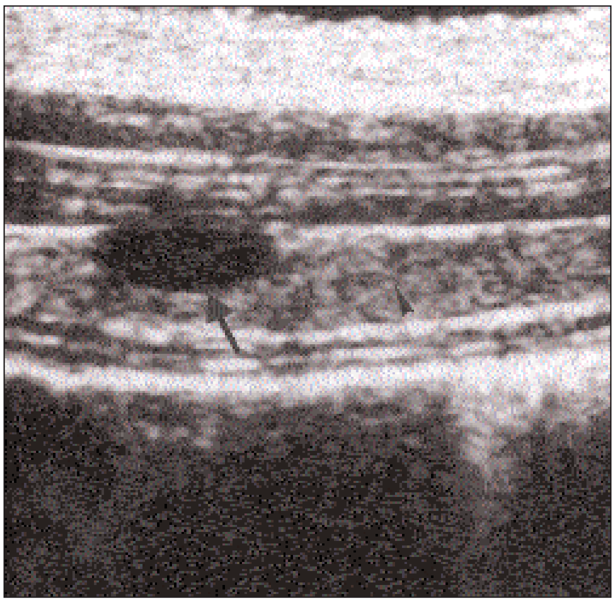

Figure 4—Ultrasonogram of a cranial parathyroid gland of a dog with chronic renal failure (longitudinal section). The shape of the parathyroid gland (arrow) is similar to that in Figure 2, but the gland is larger and less echogenic and, thus, easier to differentiate from the surrounding thyroid tissue (arrowhead; size, 5.6 mm).

tion ranged from 29 to 145 mmol/L (median, 76 mmol/L), and serum creatinine concentration varied from 454 to 990 µmol/L (median, 735 µmol/L). Significant differences were not detected between the 2 groups with respect to BUN, serum creatinine, serum phosphorus, and serum potassium concentrations, urine specific gravity, and Hct.

In dogs with ARF, the ultrasonographic characteristics of the parathyroid glands with respect to shape and echogenicity were similar to those of control dogs. In 1 (14%), 5 (72%), and 1 (14%) of the dogs with ARF, 4, 3, and 2 parathyroid glands, respectively, were evident. Size of the parathyroid glands ranged from 2.4 to 4.0 mm (median, 2.7 mm). Significant differences were not detected between control dogs and dogs with ARF with respect to parathyroid gland size. Additionally, body weight did not differ between the 2 groups (**Fig 3**).

In dogs with CRF, the parathyroid glands were always anechoic and more distinctly demarcated from surrounding thyroid tissue, compared with controls and dogs with ARF (**Fig 4**). In 8 (62%), 3 (23%), and 2 (15%) dogs with CRF, 4, 3, and 2 parathyroid glands, respectively, were evident. Size of the parathyroid glands ranged from 3.9 to 8.1 mm (median, 5.7 mm). There were no differences in body weight among control dogs, dogs with ARF, and dogs with CRF. However, the parathyroid glands of dogs with CRF were significantly larger than those of control dogs ($P < 0.001$) and dogs with ARF ($P = 0.003$). With 1 exception, in each weight category, the smallest parathyroid gland in dogs with CRF was larger than the largest gland in the control dogs and in dogs with ARF.

## Discussion

Increase in size of the parathyroid glands because of hyperplasia and hypertrophy is characteristic of CRF.[4] For the purpose of this study, we postulated that in dogs with ARF, the parathyroid glands would be normal in size and ultrasonographic appearance, whereas in dogs with advanced CRF, an enlargement of the parathyroid glands would be detectable ultrasonographically. To the authors' knowledge, there are no published studies of the normal size of the parathyroid glands in healthy dogs. Wisner et al[7] assumed that the parathyroid glands in healthy dogs are quite small and usually cannot be detected ultrasonographically. Typically, a dog has 4 parathyroid glands. Two cranial glands are usually located on the cranial dorsolateral surface of the thyroid gland, and 2 caudal glands with a more variable location are usually embedded in the caudal thyroid tissue. In this study, using a 10-MHz high-resolution linear transducer, 4 parathyroid glands were evident in 12 of 23 healthy dogs. In most (9/12) of these dogs, the cranial parathyroid glands were larger than the caudal glands. In 1 dog, the caudal pair of glands was larger; in 1 dog, the caudal pair was the same size as the cranial pair; and in 1 dog, the cranial glands were the same size as the caudal glands on the contralateral side. In the remaining healthy dogs, only 3 (7 dogs) or 2 (4 dogs) parathyroid glands were evident. Possible reasons for this include small size of the glands, insufficient contrast between parathyroid and thyroid tissue on the ultrasonogram, atypical location of the parathyroid glands, or congenital variations in the number of parathyroid glands. The latter seems unlikely for such a large number of dogs (11/23 dogs). Parathyroid glands with an atypical location can be difficult to find. In this study, there was considerable deviation from the typical location of the parathyroid glands. However, with some experience and thorough searching, parathyroid glands that are cranial or caudal to the thyroid gland or those located at the angle between the trachea and the thyroid gland or between the carotid artery and the thyroid gland should be evident. We could not rule out that in some dogs, individual parathyroid glands were situated at the thoracic inlet or in the mediastinum and, thus, were not accessible to ultrasonographic examination. Furthermore, some parathyroid glands may have had a high lipid content, which would decrease detection by use of ultrasonography.[9] However, we believe that the most likely explanation for our inability to image all parathyroid glands was that some glands were too small. This is supported by the positive correlation between body weight and size of the parathyroid glands and the observation that the likelihood of detecting 4 parathyroid glands increased with an increase in body weight. The positive correlation between body weight and size of the parathyroid glands indicates that assessment of the glands will most likely be related to body weight.

Dogs with CRF had significantly larger parathyroid glands than dogs with ARF. There was no difference in body weight among the 3 groups of dogs, which were all assigned to 1 of 4 groups on the basis of body weight. Within all weight groups, size of the parathyroid glands of dogs with ARF did not exceed that of control dogs. In contrast, with 1 exception, parathyroid glands of dogs with CRF were larger than those of control dogs and dogs with ARF. To our knowledge, the only data concerning parathyroid gland size in dogs with renal insufficiency are those by Wisner et al[7] in a report of 3 dogs with hypercalcemia and CRF; in 2 dogs, the parathyroid glands could not be detected ultrasonographically, and in the third, 1 gland, which was 6 mm in length, was seen. Because the body weights of the dogs were not given, it is difficult to compare the results of that study with ours. Moreover, it is difficult to assess the nature of parathyroid enlargement in dogs with hypercalcemia, because differentiation among adenoma, adenocarcinoma, and hyperplasia (primary and secondary) by use of ultrasonography is not possible.[7,8] In our study, dogs with hypercalcemia were not included.

In humans, it is known that hyperplasia of the parathyroid glands in CRF is a gradual process and does not affect all glands simultaneously.[9,10] In 1 report,[9] the number of abnormal parathyroid glands was strongly correlated with the duration of hemodialysis. In addition, the echogenic pattern of the gradually enlarging parathyroid gland in humans changes so that it is more easily detectable ultrasonographically.[9] Such studies have not been reported in dogs, although results of our study indicated that a similar process may develop in dogs. Instances in which 4 parathyroid glands were evident were more common in dogs with CRF than in dogs with ARF and controls (62 vs 52 and 14%, respectively). Furthermore, compared with control dogs, the parathyroid glands of dogs with CRF were more prominent ultrasonographically and consistently anechoic. However, whether the number of enlarged and clearly visible parathyroid glands is related to the duration of CRF should be determined in future studies involving larger numbers of dogs in various stages of CRF.

In this study, dogs with severe azotemia were chosen, and all dogs required immediate treatment because of their poor general condition. In all dogs, the type of renal insufficiency was eventually diagnosed reliably as acute or chronic on the basis of results of various diagnostic tests. In some dogs, however, a definitive diagnosis (CRF vs ARF) had not yet been made at the time of ultrasonographic examination. This situation happens commonly in practice and may complicate the decision regarding the intensity of treatment. Certain clinical findings can be helpful but may not be sufficient for definitive differentiation of ARF and CRF. For example, in this study, results of laboratory tests, including Hct and serum potassium concentration, did not differ between dogs with ARF and CRF. Although a kidney biopsy would allow a reliable diagnosis in most instances, clinicians may hesitate to perform this procedure, particularly in critically ill patients, because it requires general anesthesia and is invasive.

Detection of the parathyroid glands ultrasonographically is possible with some experience. The limiting factor, however, may be the quality of the equipment, because it is best performed with a linear transducer (10 to 13 MHz). On the basis of results of this study and those in human medicine, we concluded that ultrasonographic examination of the parathyroid glands is a useful aid in differentiating ARF and CRF in dogs with severe azotemia.

[a]Accuson Sequoia 512, Mountain View, Calif.
[b]SPSS/PC version 6.0 base manual, SPSS Inc, Chicago, Ill.

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