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Renal Cell Carcinoma (RCC) in dogs: Cytological and haematobiochemical findings of three cases

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Abstract
Renal cell carcinoma (RCC) was diagnosed in three dogs based on cytological examination of samples from tumour suspected renal masses. All three cases were diagnosed from samples collected from right kidney. In breed, sex and age wise occurrence, two cases were recorded in German shepherd breed and one case was recorded in Labrador breed, two cases were recorded in male dogs and a lone case was recorded in female dog and age of tumour affected dogs ranged between 1 to 7 years. Cytologic examination revealed sheets of round to polyhedral neoplastic cells without clear cytoplasmic outlines, round to oval nuclei containing single, prominent nucleoli to inconspicuous nucleoli and basophilic cytoplasm containing small to medium sized clear vacuoles. Anaemia, polycythaemia, leukocytosis, thrombocytosis, thrombocytopenia, elevated BUN and hypoalbuminaemia were the haematobiochemical changes recorded in the tumour affected dogs.

Keywords: Dog, tumours, renal cell carcinoma, RCC, cytology, haematobiochemical changes

Introduction
Renal disorders have emerged as a significant concern in canine clinical practice in recent years, with impairment of kidney function resulting from a wide range of multifactorial causes such as infectious causes, nutritional causes, irrational use of nephrotoxic drugs, congenital and developmental anomalies; circulatory disturbances like hypertension, ischemia; bleeding and clotting disorders; inflammation of kidneys-glomerulonephritis, pyelonephritis, interstitial nephritis and other components of urinary system and neoplasms of renal system occurring either as a primary tumour of kidneys or tumours metastatic from other organs like prostate, adrenals, liver etc (Subapriya *et al*. 2020) [18].
Primary renal neoplasia in dogs is relatively uncommon, accounting for only 0.3% to 1.5% of all canine tumours (Meuten, 2002) [13]. Among these, RCC also known as renal tubular carcinoma or renal adenocarcinoma remains the most frequently diagnosed primary renal malignancy in dogs (Borjesson, 2003) [3]. Notably, Carvalho *et al*. (2017) [6] reported that RCC comprises approximately 49% to 65% of all primary renal neoplasms, underscoring its clinical and pathological relevance in veterinary oncology.
The spectrum of clinical signs associated with RCC is largely non-specific and may include anorexia, lethargy, vomiting, weight loss, pale mucous membranes, polydipsia, polyuria, haematuria, and abdominal pain on palpation. Waters and Prueter (1988) [23] reported that clinical signs such as polyuria and polydipsia, along with erythema of the skin and mucous membranes and the occasional neurological signs in renal disorders may be attributed to secondary polycythaemia associated with renal disease.
A multimodal diagnostic approach is essential for the accurate diagnosis of RCC in dogs. Cytology, histopathology, and imaging modalities such as ultrasonography and computed tomography (CT) play a crucial role in the identification and confirmation of renal carcinomas. Noh *et al*. (2022) [15] reported that CT is the most effective imaging tool for visualizing renal tumour masses and for the close monitoring of metastatic spread from primary renal tumours in dogs and cats.

Cytology is a valuable, safe, minimally invasive and practical tool for the preliminary diagnosis of neoplasms in dogs, particularly in clinical settings requiring rapid diagnostic results to facilitate timely medico-surgical intervention (Subapriya *et al*., 2025) [20]. According to Borjesson (2003) [3], renal cytology is particularly useful for identifying both primary and metastatic renal neoplasms, as well as non-neoplastic conditions such as inflammation, abscesses and infections of the kidneys.

The prognostic outcome of canine RCC is variable. Lucke and Kelly (1976) [11] reported a maximum survival time of up to four years following nephrectomy, while Bryan *et al*. (2006) [4] observed that dogs undergoing nephrectomy survived longer than untreated dogs or those receiving only medical therapy. The most common metastatic sites of RCC in dogs include the lungs, regional lymph nodes, bones, skin and liver (Herthel *et al*., 2011) [8] and a significantly shorter median survival time was observed in dogs with metastatic RCC (mRCC) compared to those without metastasis at the time of diagnosis (Carvalho *et al*., 2017) [6].

Following confirmation of RCC, clinicopathological monitoring is required to assess the functional status of the kidneys. Evaluation of renal impairment in dogs typically includes serum biochemical analysis to detect elevated blood urea nitrogen, increased serum creatinine, hyperphosphataemia, electrolyte imbalances and hypoalbuminaemia along with urinalysis to assess urine specific gravity and to identify abnormalities such as proteinuria, haematuria, and urinary casts (Subapriya *et al*., 2020) [19].

Based on the above information, the present study was undertaken to gain deeper insights into the cytological features and haemato-biochemical alterations associated with canine RCC, as well as to evaluate the potential risk factors influencing its occurrence in dogs.

Materials and Methods

Clinical samples collected from dogs presented to the Madras Veterinary College Teaching Hospital (MVCTH), Chennai-07, and clinically suspected for renal neoplasia based on physical examination and ultrasonographic findings formed the basis of the present study. Fine-needle aspiration cytology (FNAC) samples, along with blood and serum, were processed at the Centralized Clinical Laboratory, Madras Veterinary College, Chennai-07. Blood and serum analyses were carried out using automated haematology and biochemistry analysers.

Smears prepared from FNAC samples were air-dried and stained with a Leishman-Giemsa (LG) cocktail stain for the cytological identification of renal neoplasms. Morphological criteria for tumour identification were based on cell shape and size; cellular arrangement; nuclear shape; chromatin density; nucleolar number, size and distribution; cytoplasmic volume and basophilia, cytoplasmic vacuolation; nucleus-to-cytoplasm ratio and the presence of mitotic figures as described by Subapriya *et al*. (2021) [17].

For each confirmed case of RCC, information on breed, sex, age and sample collection site was retrieved from the sample requisition form to analyse the predisposition of these factors in the occurrence of the tumour.

Results and Discussion

RCC was diagnosed in three dogs in the present study based on cytological evaluation of samples submitted from dogs suspected of having renal tumours, as indicated by clinical examination findings, abdominal palpation, and ultrasonographic assessment. The cases were recorded in a one year-male-Labrador dog, seven years-male-German shepherd dog and in a six years-female-German shepherd dog. This accounted for an incidence of 0.05% of all tumours diagnosed in dogs during the study period. The prevalence recorded in this study was lower than that reported by Bellini *et al*. (2020) [1], who stated that RCC accounts for 0.5-1.5% of all canine tumour types and is a highly aggressive, rapidly growing, and metastasis-prone neoplasm, often culminating in the death of the affected animal. This variation may be attributable either to a genuinely lower incidence of the tumour in the population or to the non-specific clinical signs of RCC, which often result in under-recognition of cases within the canine population and consequently reduced presentation of affected animals to veterinary hospitals for ultrasonographic or clinicopathological diagnosis.

Breed, Sex, Age and Location

In the breed-wise analysis, of the three confirmed cases of RCC, two were recorded in German Shepherd dogs. This finding aligns with the observations of Kwon *et al*. (2018) [10], who reported a predisposition of German Shepherds to develop renal tumours. With respect to sex distribution, two cases occurred in male dogs and one in a female, which concurs with Lucke and Kelly (1976) [11] who reported that male dogs are more frequently affected by renal carcinomas than females.

With regard to age, one case each was diagnosed in dogs aged one, six, and seven years, indicating an age range of 1-7 years among the affected dogs in the present study. Previously, Lucke and Kelly (1976) [11] documented an age range of 3-15 years for RCC, while Bryan *et al*. (2006) [4] reported an even wider age range of 1-17 years at the time of presentation.

All three cases in the present study were diagnosed from FNAC samples submitted from the right kidney. By contrast, Bryan *et al*. (2006) [4] reported that renal tumours occur with equal frequency in both kidneys, with bilateral involvement recorded in approximately 4% of cases.

Cytological findings

In cytological evaluation, the smears revealed high cellularity. The neoplastic cells were seen as sheets of round to polyhedral cells without clear cytoplasmic outlines. Nuclei appeared round to oval containing single, prominent nucleoli to inconspicuous nucleoli in many fields. Cytoplasm appeared basophilic and contained small to medium sized clear vacuoles. Mild to moderate anisocytosis and anisokaryosis was observed. Mitotic figures were rarely demonstrable. The neoplastic cells were found to be accompanied with erythrocytes. Similar cytological descriptions of RCC have been described by Burton (2017) [5] and accordingly RCC was confirmed by cytological features recorded in the study. Representative cytological findings are presented in Fig. 1-3.

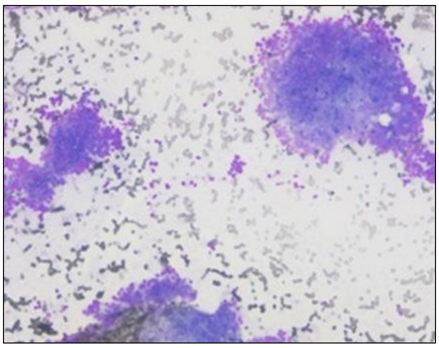

Fig 1: RCC - Multifocal clusters of hyperchromic neoplastic cells - LG stain x 100

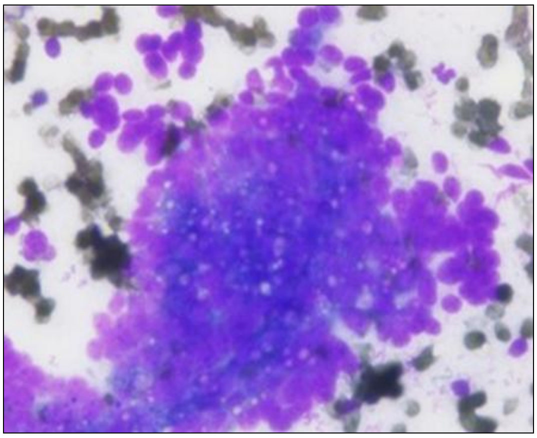

Fig 2: RCC - Cluster of hyperchromic neoplastic cells - Anisokaryosis - LG stain x 400

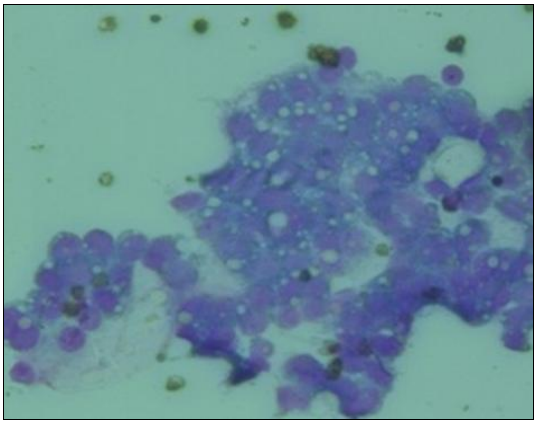

Fig 3: RCC - Anisocytosis - Anisokaryosis - Pleomorphic vacuolation - LG stain x 400

Haematological changes

Haematological evaluation of the three RCC-affected dogs revealed abnormalities including anaemia, polycythaemia, leukocytosis, neutrophilia, thrombocytosis and thrombocytopenia. Anaemia was detected in two dogs, while polycythaemia was observed in one dog, as indicated by reduced or elevated haemoglobin concentration (g/dL), packed cell volume (%), and total erythrocyte count (million/cmm) on automated haematology analysis, and subsequently confirmed by microscopic examination of Leishman-Giemsa stained peripheral blood smears. Leukocytosis, predominantly neutrophilic, was recorded in two dogs, while one dog each exhibited thrombocytopenia and thrombocytosis.

The haematological alterations observed in this study are consistent with the paraneoplastic effects of renal neoplasia, particularly the inappropriate production of erythropoietin and its influence on bone marrow function. The present findings partially correlate with those of Bryan *et al.* (2006) [4], who reported anaemia (33%), leukocytosis (20%), lymphopenia (9%), thrombocytopenia (9%), monocytosis (6%) and less frequently polycythaemia as haematologic abnormalities in canine RCC. Similarly, Meuten and Meuten (2016) [12] also stated that dogs with RCC exhibit neutrophilic leukocytosis, mild anaemia, mild thrombocytopenia and polycythaemia due to increased erythropoietin production. Neeladevi *et al.* (2024) [14] also reported thrombocytopenia in dogs with renal impairment due to infectious and neoplastic causes.

Von Knorring (1981) [22] attributed the haematological anomalies in renal carcinoma to tumour-induced mechanisms, including ectopic production of erythropoietin or thrombopoietin, bone marrow metastasis, altered phagocytic and chemotactic responses, or immune-mediated processes. Waters and Prueter (1988) [23] proposed two mechanisms for erythropoietin elevation in renal tumours: autonomous overproduction and secretion of erythropoietin by the tumour cells, and/or secondary stimulation of normal renal erythropoietin-producing cells due to tumour-induced hypoxia from compression of renal parenchyma or impaired renal blood flow.

The neutrophilic leukocytosis recorded in two cases is further supported by the findings of Petterino *et al.* (2011) [16], who demonstrated granulocyte/macrophage colony-stimulating factor (GM-CSF) expression by tumour cells in canine RCC mediating paraneoplastic leukocytosis. However, given the small sample size and variability in haematological alterations observed, further studies involving a larger population of dogs are warranted to better characterise the haematological changes associated with RCC.

Serum biochemical changes

Serum biochemical analysis of the RCC-affected dogs revealed elevated blood urea nitrogen (BUN) in a case and hypoproteinaemia and hypoalbuminaemia in another case. Creatinine, a more specific indicator of renal impairment, remained within the normal range in all dogs diagnosed with RCC in the present study. This observation is supported by Klausner and Caywood (1995) [9], who reported that clinical signs of renal failure may not be evident even in cases of RCC with neoplastic involvement of both kidneys, as only 25% of functional renal parenchyma is sufficient to maintain normal renal function. Similarly, Veena *et al.* (2020) [21] reported that serum creatinine values generally remain within the reference range until renal function declines to below 25% of its normal capacity.

In agreement with the present findings, Bennett (2004) [2] recorded hypoalbuminaemia in a dog with unilateral RCC, attributing it to increased renal protein loss combined with reduced hepatic protein synthesis. Similar biochemical alterations, particularly hypalbuminaemia, have also been documented in dogs with RCC by Fm *et al.* (2004) [7] and Carvalho *et al.* (2017) [3].

Conclusion

- `The study emphasized the value of FNAC as a safe, rapid, and minimally invasive diagnostic tool for the detection of RCC by observing the distinctive cytomorphological attributes of RCC in microscopic examination of FNAC samples in dogs. It also documented the key haematological and biochemical alterations associated with the condition and potential breed and sex predispositions. RCC was confirmed in three dogs during the study period, reflecting its low incidence in clinical practice. Despite the low occurrence, a possible predisposition among German Shepherds and male dogs was recorded, suggesting that clinicians should maintain a higher index of suspicion in these groups when renal neoplasia is suspected. Future research involving a larger cohort of dogs, and incorporating advanced diagnostic approaches such as immunocytochemistry, molecular markers, and longitudinal follow-up is recommended to more accurately establish epidemiological trends, risk factors, and prognostic markers of canine RCC.
- The haematological and biochemical abnormalities observed such as anaemia, polycythaemia, leukocytosis,

thrombocytosis or thrombocytopenia, elevated BUN, and hypoalbuminaemia underscored the need for veterinarians to consider paraneoplastic syndromes and subtle renal dysfunction when interpreting laboratory findings in dogs with renal masses. Notably, serum creatinine remained within normal limits in all cases, reinforcing that renal function may appear clinically normal until the later stages of disease progression, thereby emphasizing the need for comprehensive diagnostic profiling beyond conventional renal markers.

- From a clinical standpoint, the non-specific manifestations of RCC underscores the need for heightened clinical awareness and for integrating cytology, imaging, and clinicopathological evaluation to facilitate timely diagnosis of RCC as early recognition and confirmation of RCC is crucial for guiding appropriate therapeutic interventions and improving clinical outcomes in the RCC-affected dogs.

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Conflict of Interest
Not available

Financial Support
Not available

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