Study of development changes in kidneys of dogs by using 2D and 3D ultrasonography

Dinesh*, S.M. Behl, Prem Singh, Rishi Tayal, Madan Pal and R.K. Chandolia1

Department of veterinary Surgery and Radiology, LLRUniversity of Veterinary and Animal Sciences, Hisar-125004, India.

Received: 22-05-2015 Accepted: 28-07-2015

ABSTRACT

The present study was undertaken in six apparently healthy pups of mixed mongrel breed from the same litter, to study developmental changes using 3D ultrasound machine (Nemio-XG: Toshiba, Japan). In kidneys the cortex appeared hypoechoic and medulla was anechoic up to 3rd month of age, where as the same was hyperechoic and medulla was hypoechoic up to end of the study (8th month). The kidney parameters observed were length, width, circumference, cortical thickness and medullary thickness, which showed linear increase with age. In 3D appearance of the renal structures (renal pelvis, renal sinus) were clearer than 2D ultrasonogram.

Key words: Anechoic, Hypoechoic, Hyperechoic, Kidney, Ultrasonography.

INTRODUCTION

The kidneys and urinary bladder can be easily imaged by radiological techniques for diagnostic purposes. Ultrasonography is more sensitive than radiography for small parenchymal masses and changes in internal architecture of the kidney (Konde et al., 1986). The radiographic magnification and incomplete visualisation of kidney in radiograph leads to inaccurate evaluation of renal size. Renal ultrasonography is a non invasive imaging technique which allows characterization of internal renal architecture. The major advantage of ultrasonography is its ability to discriminate changes among renal capsule, cortex, medulla, pelvic diverticula and renal sinus (Konde et al., 1984; Wood and McCarthy, 1990 and Walter et al., 1987). Ultrasound provides a rapid estimation of kidney dimensions that prove beneficial for the determination of renal size in the dogs (Nyland et al., 1989). The appearance and location of the kidneys in dogs are affected by the age, posture and general body condition. In dogs there are unilobar kidneys with smooth surface and a single renal papilla. The kidneys are paired structure lying against the sublumbar muscle on each side of vertebral column in the retroperitoneal space. The right kidney is more cranially placed than left kidney. The right kidney is present from 13th thoracic to third lumbar vertebrae (Kealy and McAllister, 2000). The left kidney is placed below the second to fifth lumbar vertebrae. Each kidney is covered with a fibrous capsule, which is further surrounded by adipose tissue and is held in position by subperitoneal connective tissue, lie in an oblique position, tilted cranioventrally. The left kidney in dogs is in close contact with greater curvature of stomach at its anterior margin and the spleen at its dorsomedial aspect (Satish et al., 2012). They are not rigidly fixed and may move during respiration. They can also be displaced by a full stomach. The kidneys become more movable and become more ventrally and caudally directed, as the dog ages. The studies on the canine kidney and urinary bladder have been limited to the adult dogs. There are many differences between canine neonates, prepubertal animals and adults in their metabolic rate, gross anatomy and histologic differentiation of many organ systems (Poffenbarger et al., 1990). These differences influence organ size and function. The establishment of the normal variation in size and ultrasonographic appearance at different ages is of extreme importance.

MATERIALS AND METHODS

The present study was undertaken in six apparently healthy pups of mixed mongrel breed from the same litter irrespective of their sex. 1st scanning was done at 15th days of age followed by 30th, 45th, 60th days and 3rd, 4th, 5th, 6th, 7th and 8th month of age. The pups were kept off feed for 12 hours prior to ultrasonography to allow clearance of the solid content from GI tract and provided ad-lib fluid for a better acoustic window for scanning. For scanning of kidneys ventral abdomen was shaved and pups were controlled in lateral recumbency i.e. left lateral recumbency for right kidney and right lateral recumbency for left kidney. The left kidney was scanned below the transverse process of first to third lumbar vertebrae and for the right kidney, in addition an intercostal approach through the last or second last intercostal space was used to scan it in its transverse plane. Each kidney was scanned in its transverse plane, a

*Corresponding author’s e-mail: dd2012vets@gmail.com
1Department of veterinary Gynaecology and Obstetrics, LLRUniversity of Veterinary and Animal Sciences, Hisar-125004, India.
longitudinal and sagittal plane. Appearance of a C-shaped image in the middle of kidney indicated a proper transverse plane. In the longitudinal scan, a bright renal sinus was visible in the centre or eccentric location of the kidney. In the sagittal plane, two bright parallel echogenic bars were visualised in the centre of the kidney. The ultrasound machine used for this study was 3D ultrasound machine (Nemio-XG: Toshiba, Japan) having 4D volumetric probe. The statistical analysis of data was done by one-way-analysis of variance and Duncan’s multiple range tests was used to compare the means.

RESULTS AND DISCUSSION

At the 15th day (Fig. 1) of age there was no differentiation between cortex and medulla and the renal parenchyma appeared as a hypoechoic structure. Reduction in echogenicity of cortex was observed at two weeks of age. At 30th day of age (Fig. 2) in 2D ultrasonogram the renal capsule was visualized as an echogenic rim. The renal cortex was uniformly visible on the periphery of the kidney. The corticomedullary junction was well-defined. The renal crest appears in the centre as thick straight bright line. The renal medulla was visualized as an anechoic region in the central portion of the kidney. Four echogenic renal diverticulae radiated from the region of the renal pelvis and divide the medulla. These diverticulae represented borders of interlobar vessels. At 180th day of age in 2-D ultrasonogram (Fig. 3) all the renal structure renal sinus, renal diverticulae, arcuate arteries and corticomedullary junction were clearly visible. All these structures were visualized since one month of age. The only difference comes with age was increased dimensions of different renal parameters. At 210th (Fig. 4) and 240th day (Fig. 5) of age in 2-D ultrasonogram visualization of kidney was similar as at 180th day of age. Small increase in all the renal parameters was observed. The cortex and medulla appeared separately with well defined corticomedullary junction from one month to eight months of age. The echogenicity of cortex was found to be increased with age and this increase was more pronounced up to four month of age. England (1996) observed that the kidney imaged from one month of age onwards was similar in

Fig 1: Normal 2D sonogram of kidney at 15th day of age. Kidney parenchyma(red arrow) without differentiation of cortex and medulla. Hyperechoic renal crest (yellow arrow).

Fig 2: Normal 2D sonogram of kidney at 30th day of age. Cortex hypoechoic (red arrow) and medulla anechoic (yellow arrow). Hyperechoic renal diverticulae (black arrow) start appearing.

Fig 3: Normal 2D sonogram of kidney at 180th day of age. Cortex hypoechoic (red arrow) and medulla anechoic (yellow arrow). Hyperechoic renal diverticulae (blue arrow).

Fig 4: Normal 2D sonogram of kidney at 210th day of age. Cortex hyperechoic (black arrow) and medulla anechoic (yellow arrow). Hyperechoic renal diverticulae (red arrow) and renal crest (green arrow).
ultrasonographic appearance to those of adults. The increased
cortical echogenicity may be related to accumulation of
calcium or collagen (Rosenfield and Siegel, 1981 and Barr
et al., 1989). From one month of age (Fig. 2) the renal
medulla appeared distinctly. It was anechoic at one month
of age and becomes hypoechoic from fourth month onwards.
The paucity of echoes from the medulla occurs due to higher
water content, fewer acoustic interfaces, presence of
predominantly thin walled straight tubular loops and the
collecting ducts (Wood and McCarthy, 1990 and Finn-
Bodner, 1995). Echogenic renal diverticulae started
appearing in the medulla from one month of age. Singh
(2004) also observed renal diverticula at three months of
age where as England (1996) reported the echogenic renal
diverticulae radiated from the renal pelvis at one month of
age.

In 3-D ultrasonogram at 15th day of age (Fig.6) the
kidney contour was better differentiated from the surrounding
tissue than 2-D ultrasonogram. The renal parenchyma
appeared as a homogenous tissue up to 45th day (Fig. 7) of
age and the renal sinus and contour of the kidney were better
visualized. At 90th day of age (Fig. 8) in 3D ultrasonogram
renal cortex and medulla were visualized separately. The
cortex appeared as a rim around the medulla. The medulla
was divided by the diverticulae. The different compartments
of medulla were clearly visible. At 180th day of age (Fig. 9)
in 3-D ultrasonogram the internal renal architecture was
clearly visualized. The renal vessels and renal pelvis were
not visualized in the 2-D ultrasonogram. These structures
were visible in 3-D ultrasonogram. At 240th day of age
(Fig. 10) in 3-D ultrasonogram visualization of kidney was
also similar to previous reading with increased size. There
was no difference between left and right kidney images. The
division of medulla in to different compartments by
diverticulae was more clearly visible in 3-D ultrasonogram.

The renal sinus contains the renal pelvis, adipose
tissue and vessels. In 2-D ultrasonogram the renal sinus was
identified as a moderately echogenic area in the centre at
15th day of age. Similar to findings of England (1996) at
this stage where the vessels at the hilus of kidney were not

![Fig 5: Normal 2D sonogram of kidney at 240th day of age. Cortex hyperechoic (red arrow) and medulla anechoic (yellow arrow). Hyperechoic renal diverticulae (green arrow) and renal crest (black arrow).](image)

![Fig 6: Normal 3D sonogram of kidney at 15th day of age. Well distinct kidney margins (yellow arrow) and renal crest in centre (red arrow).](image)

![Fig 7: Normal 3D sonogram of kidney at 45th day of age. Kidney parenchyma appears as a homogenous tissue without distinction of cortex and medulla (black arrow).](image)

![Fig 8: Normal 3D sonogram of kidney at 90th day of age. Cortex (black arrow) and medulla (green arrow) appears distinctly.](image)
and left kidneys. The cortex and medulla of the kidneys grow at the same rate. However, Barr, (1990) found small but significant differences in the dimensions of left and right kidneys. The cortex and medulla thickness of right kidney were measured in the previous reports of renal parameters. The difference between parameters of right and left kidneys was not measured in the previous reports of renal parameters, but Barr, (1990) found small but significant differences in the dimensions of left and right kidneys. The difference was not measured in the previous reports of renal parameters.

Table 1: Ultrasonographic measurements of right kidney with the advancement of age

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
<th>210</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters (mm)</td>
<td>Width</td>
<td>18.51±0.65</td>
<td>22.99±0.33</td>
<td>23.60±0.55</td>
<td>24.45±1.44</td>
<td>26.17±1.37</td>
<td>28.92±0.34</td>
<td>30.62±1.98</td>
<td>32.23±3.39</td>
<td>32.33±0.61</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>29.32±0.64</td>
<td>31.80±0.74</td>
<td>35.00±1.78</td>
<td>41.23±0.77</td>
<td>41.93±4.48</td>
<td>44.95±0.60</td>
<td>51.01±1.13</td>
<td>52.28±0.50</td>
<td>52.75±1.18</td>
</tr>
<tr>
<td></td>
<td>Circumference</td>
<td>87.72±2.28</td>
<td>94.28±0.69</td>
<td>107.32±1.18</td>
<td>119.57±2.55</td>
<td>119.63±3.26</td>
<td>125.67±2.34</td>
<td>140.90±3.85</td>
<td>141.47±4.01</td>
<td>149.18±2.57</td>
</tr>
<tr>
<td></td>
<td>Cortical thickness</td>
<td>5.13±0.08</td>
<td>6.35±0.14</td>
<td>6.67±0.28</td>
<td>7.27±0.13</td>
<td>7.98±0.46</td>
<td>8.65±0.39</td>
<td>11.18±1.33</td>
<td>12.32±0.29</td>
<td>13.01±0.49</td>
</tr>
<tr>
<td></td>
<td>Medullary thickness</td>
<td>7.55±0.15</td>
<td>7.68±0.11</td>
<td>8.00±0.31</td>
<td>8.25±0.21</td>
<td>9.35±0.41</td>
<td>10.65±0.36</td>
<td>11.97±0.56</td>
<td>14.70±0.87</td>
<td>14.88±0.76</td>
</tr>
</tbody>
</table>

Table 2: Ultrasonographic measurements of left kidney with the advancement of age

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>180</th>
<th>210</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters (mm)</td>
<td>Width</td>
<td>17.65±0.50</td>
<td>18.77±0.47</td>
<td>22.33±0.69</td>
<td>23.20±0.97</td>
<td>23.85±0.74</td>
<td>25.77±0.95</td>
<td>26.07±0.50</td>
<td>27.38±0.90</td>
<td>28.40±0.59</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>26.65±0.89</td>
<td>29.05±0.67</td>
<td>40.75±0.81</td>
<td>42.12±1.58</td>
<td>41.93±4.48</td>
<td>44.85±1.97</td>
<td>47.10±0.60</td>
<td>48.00±0.78</td>
<td>48.10±0.79</td>
</tr>
<tr>
<td></td>
<td>Circumference</td>
<td>75.77±1.33</td>
<td>87.02±2.29</td>
<td>102.22±0.48</td>
<td>118.57±2.06</td>
<td>120.57±2.36</td>
<td>133.50±2.68</td>
<td>134.25±2.86</td>
<td>141.55±0.55</td>
<td>141.22±3.44</td>
</tr>
<tr>
<td></td>
<td>Cortical thickness</td>
<td>6.70±0.12</td>
<td>6.70±0.12</td>
<td>6.93±0.10</td>
<td>7.82±0.33</td>
<td>7.90±0.25</td>
<td>9.18±1.25</td>
<td>9.87±1.32</td>
<td>10.35±1.23</td>
<td>11.35±0.22</td>
</tr>
<tr>
<td></td>
<td>Medullary thickness</td>
<td>7.12±0.12</td>
<td>7.76±0.38</td>
<td>8.97±0.08</td>
<td>9.12±0.97</td>
<td>10.03±0.96</td>
<td>10.43±0.49</td>
<td>11.42±1.33</td>
<td>14.62±1.15</td>
<td>14.70±0.87</td>
</tr>
</tbody>
</table>
medullary thickness were also increased linearly in both the kidney. Felkai et al (1992) considered that the variation in the various renal parameters occurs due to limited visual acuity of the observer while observing an ultrasonogram. This results in the imaging of imprecise organ margins (Walter et al., 1987) and failure to image the kidney in its greatest dimension (Rosenbaum et al., 1978). Felkai et al., (1992) observed that it was occasionally difficult to define the renal border at the hilus, probably because of presence of connective tissue.

REFERENCES