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Abstract: Computed tomographic (CT) findings of the urinary tract and adrenal glands of five healthy male calves in the first 105 days of life were compared with corresponding cadaver slices. The structures seen on CT images were identified using the corresponding cadaver slices. CT produced exact images of the kidneys, urinary bladder, urethra and adrenal glands, but reliable images of the ureters were only obtained near the renal hilus. There was excellent agreement between the structures on the CT images and the tissue slices. The structure and vessels of the kidneys, the origin of the ureters, the location, size and content of the urinary bladder and the course of the urethra in the pelvis and penis were evident on images. The size and volume of the kidneys and the length and width of the adrenal glands increased significantly during the study, but the ureteral and urethral diameters changed little.

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Computed tomography of the abdomen of calves during the first 105 days of life: III. Urinary tract and adrenal glands

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Summary

Computed tomographic (CT) findings of the urinary tract and adrenal glands of five healthy male calves in the first 105 days of life were compared with corresponding cadaver slices. The structures seen on CT images were identified using the corresponding cadaver slices. CT produced exact images of the kidneys, urinary bladder, urethra and adrenal glands, but reliable images of the ureters were only obtained near the renal hilus. There was excellent agreement between the structures on the CT images and the tissue slices. The structure and vessels of the kidneys, the origin of the ureters, the location, size and content of the urinary bladder and the course of the urethra in the pelvis and penis were evident on images. The size and volume of the kidneys and the length and width of the adrenal glands increased significantly during the study, but the ureteral and urethral diameters changed little.

Keywords: computed tomography, cattle, calf, urinary tract, kidney, urinary bladder, ureter, urethra, adrenal glands

Computertomographie des Abdomens von Kälbern vom ersten bis zum 105. Lebenstag: III. Harnapparat und Nebennieren

In der vorliegenden Arbeit werden die computertomographischen (CT) Befunde an Harnapparat und Nebennieren von 5 gesunden männlichen Kälbern von der Geburt bis zum Alter von 105 Tagen beschrieben und mit denjenigen der postmortalen Untersuchung verglichen. Nieren, Harnblase, Urethra und Nebennieren konnten computertomographisch exakt dargestellt werden, während die Ureteren nur im Bereich des Hilus renalis zuverlässig identifiziert werden konnten. Die Topographie der Organe bzw. der Strukturen und der anatomischen Schnittpräparate stimmten sehr gut überein. An den Nieren waren die Struktur und die Blutgefässe, an den Ureteren deren

Anfangsteil, an der Harnblase Lage, Grösse und Inhalt und an der Urethra der Verlauf im Becken und Penis zu sehen. Die Ausdehnung und das Volumen der Nieren nahmen von der ersten bis zur sechsten Untersuchung signifikant zu. Das Gleiche gilt für die Länge und Breite der Nebennieren, während sich die Durchmesser von Ureteren und Urethra kaum veränderten.

Schlüsselwörter: Computertomographie, Rind, Kalb, Harnapparat, Niere, Harnblase, Ureter, Urethra, Nebennieren

Introduction

Computed tomography (CT) is an established imaging modality for the examination of the urinary tract in cats and dogs. It has also been used to study the urinary tract in adult goats by comparing transverse, dorsal and sagittal CT images with corresponding anatomical cadaver slices (Irmer, 2010; Braun et al., 2011c). Diagnostic procedures in calves with suspected urinary tract disorders include clinical examination, urinalysis, haematological analyses, radiography, cystoscopy (in nanny goats) and ultrasonography (Weisser, 2000). Computed tomography is indispensable for the diagnosis of urinary tract disorders in humans (Dobry and Danuser, 2009) and small animals. Because there have been no CT studies of the urinary tract in calves, the goal of this investigation was to document CT findings of the urinary tract in five healthy male calves in the first 105 days of life and to compare the findings with corresponding anatomical cadaver slices.

Animals, Material and Methods

See communication I.

Kidneys

Depending on which plane provided the best images, the maximum length of the kidneys was determined in the sagittal or dorsal plane by measuring the distance between the cranial and caudal poles. The same plane was used to measure the maximum width of the kidneys, defined as the distance between the hilus and the lateral border. Multiple transverse sections were used to calculate the kidney volume (in cm³) and to determine the parenchymal density in a 4-cm² area between the hilus and the lateral border (in HU) as described in detail (Schnetzler, 2012).

Ureters

65 The diameter of both ureters was measured near the kidney in the plane that provided the best
66 images of the structures.

67

68 Urinary bladder

69 The distance between the apex of the bladder and the pelvic brim was measured in the sagittal
70 plane. The density of the urine was determined in a 5-cm² area 5 mm from the bladder wall.

71

72 Urethra

73 The urethral diameter was measured in the transverse plane.

74

75 Adrenal glands

76 The maximum length and width of the adrenal glands were measured in the plane that provided the
77 best images of these organs.

78

79 **Results**

80 All structures in the CT images could be accurately identified based on transverse, sagittal and
81 horizontal anatomical cadaver sections (Fig. 1, 2). Visual comparison of the CT images with the
82 corresponding cadaver slices was made in the transverse plane at each vertebra from the 6th thoracic
83 vertebra to the middle part of the sacrum (Schnetzler, 2012).

84

85 Kidneys

86 Both kidneys were easily identified in all calves based on the unique pattern afforded by the
87 reniculi. Contrast enhancement rendered the kidneys hyperdense relative to the surrounding tissue.

88 The density of the renal cortex was greater than that of the medulla, and the renal pelvis was
89 hypodense.

90

91 Left kidney

92 The left kidney extended from the 3rd lumbar vertebra to the sacrum but could only be identified
93 consistently at the level of the 5th lumbar vertebra (Fig. 3). In all calves, it was seen from the 4th to
94 the 6th lumbar vertebra at the first examination and from the 5th and 6th lumbar vertebra in the last
95 examination. During the study period, it became displaced by the expanding dorsal sac of the rumen
96 from the left side toward the median or sometimes into the right hemiabdomen (Fig. 4). In the dorsal

97 and sagittal planes, the left renal artery was seen running from the aorta to the kidney and in the
98 right paramedian region, the left renal vein was observed running from the kidney to the caudal vena
99 cava (Fig. 5, 6). Both blood vessels appeared as straight structures and were only a few centimetres
100 in length. They had a cranioventral course to the renal hilus until the age of three weeks, when it
101 changed to a craniodorsal course relative to the left kidney. The latter change was the result of
102 displacement of the kidney to the right paramedian region by the rumen accompanied by a rotation
103 of the renal hilus. The ureter was seen exiting from the hilar region. The left kidney underwent
104 significant growth during the study period; it was 10.8 cm long and 6.0 cm wide at the first
105 examination and 14.6 cm long and 7.1 cm wide at the last examination ($P < 0.05$) (Tab. 1). During
106 the same time period, the mean volume increased from 149.4 to 307.5 cm³ ($P < 0.05$). The mean
107 parenchymal density decreased significantly from 42.8 to 27.2 HU during the same period.
108

109 Right kidney

110 The right kidney was imaged from the 13th thoracic to the 6th lumbar vertebra (Fig. 7) but could
111 only be seen consistently at the level of the 3rd lumbar vertebra. It was seen in all calves at the level
112 of the 3rd and 4th lumbar vertebrae at the first examination and from the 2nd thoracic to 3rd lumbar
113 vertebra at the last examination. It was located retroperitoneally, embedded in perirenal fat, always
114 in the right hemiabdomen cranial to the left kidney and in contact with the liver in the renal
115 depression (Fig. 8 - 10). It appeared oval in all planes. As for the left kidney, the right renal artery
116 and vein were seen medially. The hilus and ureter exiting from the left kidney were directed
117 ventromedially. The length, width, volume and density of the right and left kidneys were similar
118 (Tab. 2).
119

120 Ureters

121 The renal attachment of the ureter at the hilus was always seen in the right kidney (Fig. 8, 9) and in
122 over 80 % of examinations of the left kidney. Both ureters ran caudally in a dorsomedial direction
123 but were only occasionally identified; their site of entry into the urinary bladder was also not usually
124 seen. The left and right ureters had similar diameters, which measured 0.3 cm on average at the first
125 examination and 0.5 and 0.7 cm, respectively, at the last examination (Tab. 1, 2).
126

127 Urinary bladder

128 The urinary bladder was identified as an oval to circular structure at the level of the sacrum on the
129 pelvic floor beneath the uterus at all examinations (Fig. 11). Depending on the degree of fill it
130 reached beyond the pelvic brim into the abdomen.

131

132 Urethra

133 The urethra was seen exiting from the neck of the urinary bladder in all three planes. It ran caudally
134 below the rectum to the ischiadic arc, where it turned back cranioventrally and continued along the
135 penis to the tip of the penis in the prepuce (Fig. 12, 13). The mean urethral diameter was 1.5 cm at
136 the first examination and 1.7 cm at the last examination (Tab. 3).

137

138 Adrenal glands

139 The adrenal glands were best seen in the transverse plane and appeared as oval to bean-shaped
140 structures. The left adrenal gland was located at the level of the cranial pole of the left kidney in the
141 immediate vicinity of the renal vessels (Fig. 6 A). It was exactly in the median and ventral to the
142 aorta and the caudal vena cava. The right adrenal gland was located medial to the hilus of the right
143 kidney and immediately cranial to or between the renal vein and artery (Fig. 14, 15). From the first
144 to the last examination, the mean length of the left adrenal gland increased from 1.01 to 1.53 cm and
145 the width from 0.66 to 0.91 cm (Tab. 4); similar increases were recorded for the right adrenal gland.

146

147 Discussion

148 The kidneys were readily identified in calves at all ages because of their unmistakable shape, the
149 unique structure of the reniculi and the strong contrast enhancement. Differentiation of
150 neighbouring organs was also aided by the surrounding hypodense perirenal fat. The size and
151 volume of the kidneys of newborn calves were the same as those of adult goats (Braun et al.,
152 2011c), but increased considerably by the age of 105 days. The length, width and volume of the left
153 kidney of goats were on average 9.3 cm, 5.0 cm and 154.9 cm³, respectively (Braun et al., 2011c),
154 compared with 14.6 cm, 7.1. cm and 307.5 cm³ in 105-day-old calves. There was considerable
155 individual variation in the density of the renal parenchyma, but there were no differences between
156 the kidneys of individual calves. This is in agreement with the results of CT of human kidneys, in
157 which the parenchyma appeared relatively homogeneous and had a density of 30 to 50 HU (Sagel et
158 al., 2002). The renal density of the calves at the last examination (27.2 HU left, 30.1 HU right) was
159 similar to that of adult goats (18.5 to 39.5 HU). A difference in density between paired kidneys of

160 more than 5 HU indicates urolithiasis in human medicine (Goldman et al., 2004). Computed
 161 tomography is the diagnostic technique of choice in people with suspected pyelonephritis (Craig et
 162 al., 2008), kidney tumours (Dobry and Danuser, 2009; Griffin et al., 2009) and kidney trauma (Lee
 163 et al., 2007), and is indispensable for the examination of patients with renal colic attributable to
 164 urolithiasis (Jindal and Ramchandani, 2007). It is likely that CT will improve the diagnosis of
 165 urinary tract diseases in calves.

166 The ureters were seen at the hilus of the right kidney in all scans and at the hilus of the left kidney in
 167 80 % of scans, but their course to and junction with the urinary bladder were only occasionally seen,
 168 in contrast to CT scans in goats (Braun et al., 2011c). We assume that dilated or otherwise diseased
 169 ureters would also be visible on CT scans in calves.

170 In contrast to the ureters, the urinary bladder and urethra were always seen at the level of the
 171 sacrum. Omphaloarteritis, omphalourachitis and various other urachal abnormalities are common
 172 problems in calves and can be diagnosed quite reliably using ultrasonography (Lischer and Steiner,
 173 1993, 1994; Lischer et al., 1994). Computed tomography should further improve images of
 174 umbilical and urachal disease processes and facilitate the planning of the surgical treatment. While
 175 ultrasonographic imaging of the urinary bladder is straightforward, imaging of the urethra of bull
 176 calves is much more difficult and reports are scant (Weisser, 2000); the penile urethra was only
 177 vaguely seen during urination. Concrement in the urethra is readily seen on radiographs and should
 178 also be visible on CT images.

179 Unlike the umbilical vein, which could be seen on CT scans until the age of three weeks
 180 (communication I), the umbilical artery was never identified caudal to the umbilicus, which was in
 181 agreement with ultrasonographic findings (Lischer, 1991; Watson et al., 1994).

182 The adrenal glands were reliably seen on CT scans, although their measurements varied greatly.
 183 Measurements of smaller structures are less precise than those of larger ones (Voorhout, 1990), but
 184 also depend on the position of the organ relative to the tomographic plane (Voorhout, 1990). The
 185 adrenal glands did not grow significantly during the study period and their size at the age of 105
 186 days corresponded to measurements obtained in adult goats and dogs (Assheuer and Sager, 1997;
 187 Braun et al., 2011c). In the calf, adrenal disease is rare and CT examination of the adrenal glands is
 188 of little clinical importance. This is in contrast to the goat, in which adrenal cortical adenoma
 189 (Smith and Sherman, 2009), medullary pheochromocytoma (De Gritz, 1997) and adrenal
 190 hypocortisolism (Swart et al., 1996; Engelbrecht et al., 2000) have been reported, although adrenal
 191 disease is generally considered to be rare.

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Conclusions

This study has shown that CT is very useful for the examination of the urogenital tract of calves. The transverse, horizontal and sagittal cadaver sections were essential for identification of the structures on CT images. This study provides reference values for CT examination of calves with suspected diseases of the urinary tract and adrenal glands.

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415 **Legend to figures**

416 Figure 1: Comparison of a transverse CT image in a soft-tissue window setting (A) and the
417 corresponding anatomical slice (B) at the level of the 3rd lumbar vertebra in a 104-day-old Holstein-
418 Friesian bull calf. 1 Right kidney, 2 Renal sinus, 3 Renal vein, 4 Right ureter, 5 Liver, 6 Rumen, 7
419 Abomasum, 8 Small intestine, 9 Large intestine, 10 Caudal vena cava, L Left, R Right.

420
421 Figure 2: Comparison of a transverse CT image in a soft-window setting (A) and the corresponding
422 anatomical slice (B) at the level of the 6th lumbar vertebra in a 104-day-old Holstein-Friesian bull
423 calf. 1 Left kidney, 2 Left ureter, 3 Caudal vena cava, 4 Aorta, 5 Rumen, 6 Small intestine, 7 Large
424 intestine, L Left, R Right.

425
426 Figure 3: Visibility of the left kidney on transverse CT images in five Holstein-Friesian bull calves.
427 The images were taken at different lumbar vertebrae and the sacrum during six CT scans in the first
428 104 days of life. The different shades of red indicate the number of calves in which the kidney was
429 visible at the respective levels. 20 %, 40 %, 60 %, 80 % and 100 %, visible in 1, 2, 3, 4 and in all
430 calves, respectively.

431
432 Figure 4: Transverse CT images of the abdomen at the level of the 1st lumbar vertebra in a one-day-
433 old (A) and at the level of the 6th lumbar vertebra in a 104-day-old Holstein-Friesian bull calf (B). 1
434 Left kidney, 2 Right kidney, 3 Aorta, 4 Left ureter, 5 Rumen, 6 Abomasum, 7 Intestines, L Left, R
435 Right.

436
437 Figure 5: Dorsal CT images of the abdomen at the level of the aorta in a 21-day-old (A) and 103-
438 day-old Holstein-Friesian bull calf (B). 1 Left kidney, 2 Right kidney, 3 Aorta, 4 Left renal vein, 5
439 Left renal artery, 6 Liver, 7 Spleen, 8 Rumen, 9 Intestines, L Left, R Right.

440
441 Figure 6: Sagittal CT images of the abdomen at the level of the left adrenal gland in a two-day-old
442 (A) and at the level of the caudal vena cava in a 103-day-old Holstein-Friesian bull calf (B). 1 Left
443 kidney, 2 Right kidney, 3 Caudal vena cava, 4 Liver, 5 Left renal vein, 6 Left adrenal gland, 7
444 Urinary bladder, 8 Abomasum, Cr Cranial, Cd Caudal.

445

446 Figure 7: Visibility of the right kidney on transverse CT images in five Holstein-Friesian bull
447 calves. The images were taken at different thoracic and lumbar vertebrae during six CT scans in the
448 first 105 days of life. The different shades of red indicate the number of calves in which the right
449 kidney was visible at the respective levels. 20 %, 40 %, 60 %, 80 % and 100 %, visible in 1, 2, 3, 4
450 and in all calves, respectively.

451

452 Figure 8: Transverse CT image of the abdomen at the level of the 4th lumbar vertebra in a one-day-
453 old Holstein-Friesian bull calf. 1 Right kidney, 2 Right ureter, 3 Caudal vena cava, 4 Aorta, 5 Left
454 kidney, 6 Liver, 7 Abomasum, L Left, R Right.

455

456 Figure 9: Dorsal CT image at the level of the aorta in a 104-day-old calf. 1 Right kidney, 2 Aorta, 3
457 Right renal vein, 4 Left kidney, 5 Urinary bladder, 6 Liver, L Left, R Right.

458

459 Figure 10: Sagittal CT image at the level of the right hip joint in a 104-day-old Holstein-Friesian
460 bull calf. 1 Right kidney, 2 Right ureter, 3 Caudal vena cava, 4 Liver, 5 Reticulum, 6 Abomasum, 7
461 Omasum, 8 Rumen, Cr Cranial, Cd Caudal.

462

463 Figure 11: Transverse CT image at the level of the sacrum in a one-day-old Holstein-Friesian bull
464 calf. 1 Urinary bladder, 2 Right ureter, 3 Left ureter, 4 Rectum, L Left, R Right.

465

466 Figure 12: Transverse CT image at the level of the pelvis in a two-day-old Holstein-Friesian bull
467 calf. 1 Penis with urethra, 2 Testes, 3 Rectum, L Left, R Right.

468

469 Figure 13: Sagittal CT image at the level of the aorta in a 40-day-old Holstein-Friesian bull calf. 1
470 Urethra, 2 Urinary bladder, 3 Testis, 4 Left kidney, 5 Aorta, Cr Cranial, Cd Caudal.

471

472 Figure 14: Transverse CT image at the level of the 2nd lumbar vertebra in a 104-day-old Holstein-
473 Friesian bull calf. 1 Right adrenal gland, 2 Caudal vena cava, 3 Right renal vein, 4 Aorta, 5 Right
474 kidney, 6 Liver, 7 Abomasum, L Left, R Right.

475

476 Figure 15: Dorsal CT image at the level of the aorta in a one-day-old Holstein-Friesian bull calf. 1
477 Right adrenal gland, 2 Caudal vena cava, 3 Right renal vein, 4 Aorta, 5 Right kidney, 6 Liver, 7 Left
478 kidney, 8 Spleen, 9 Rumen, L Left, R Right.

479 *Table 1: CT measurements of the left kidney and left ureter in five Holstein-Friesian bull calves during the first 105 days of life (mean ± sd, range).*

Variable	Examination					
	1	2	3	4	5	6
Length (cm)	10.8 ± 1.05 (9.2 – 11.8)	11.0 ± 1.72 ^a (9.0 – 12.6)	12.2 ± 1.57 ^a (10.4 – 13.5)	13.2 ± 1.11 ^{b,§} (11.6 – 14.0)	14.0 ± 1.13 ^b (12.7 – 15.5)	14.6 ± 1.09 (12.8 – 15.7)
Width (cm)	6.0 ± 0.65 (5.0 – 6.7)	5.9 ± 1.19 ^a (4.8 – 7.8)	7.6 ± 0.33 ^{a,§} (7.1 – 8.0)	7.6 ± 0.57 (7.0 – 8.5)	7.0 ± 0.93 (6.0 – 8.3)	7.1 ± 0.91 (6.3 – 8.4)
Volume (cm ³)	149.4 ± 23.64 ^a (116.5 – 177.2)	185.4 ± 29.51 ^{a,b,§} (142.0 – 224.4)	248.3 ± 26.63 ^{b,c} (217.4 – 283.7)	310.3 ± 28.5 ^c (278.4 – 348.9)	287.9 ± 31.97 ^d (248.7 – 332.9)	307.5 ± 32.67 ^d (272.8 – 358.0)
Parenchymal density (HU)	42.8 ± 3.15 (39.1 – 46.6)	44.6 ± 5.94 (34.9 – 49.2)	38.2 ± 4.77 (33.7 – 44.4)	38.8 ± 7.80 (29.7 – 50.3)	30.9 ± 11.7 [§] (14.0 – 46.4)	27.2 ± 11.81 (16.6 – 42.9)
Ureteral diameter (cm)	0.3 ± 0.08 (0.2 – 0.4)	0.3 ± 0.07 (0.2 – 0.4)	0.3 ± 0.07 ^{o,a} (0.3 – 0.4)	0.3 ± 0.13 ^a (0.2 – 0.6)	0.5 ± 0.34 ^o (0.3 – 1.0)	0.5 ± 0.12 ^{o,§} (0.4 – 0.7)

480

481 ^o Measured in 4 of 5 calves

482 ^{a, b, c, d} Within rows measurements with identical indices are different (P < 0.05)

483 [§] First significant difference compared with examination 1 (P < 0.05)

484

485 *Table 2: CT measurements of the right kidney and left ureter in five Holstein-Friesian bull calves during the first 105 days of life (mean ± sd, range).*

Variable	Examination					
	1	2	3	4	5	6
Length (cm)	11.8 ± 1.03 (10.2 – 12.7)	11.9 ± 1.51 ^a (9.5 – 13.3)	12.9 ± 1.52 ^{a,b,§} (10.4 – 14.2)	14.3 ± 1.17 ^{b,c} (12.5 – 15.7)	15.0 ± 1.32 ^c (13.0 – 16.7)	15.7 ± 1.30 (13.7 – 17.0)
Width (cm)	6.4 ± 0.82 (5.4 – 7.2)	6.5 ± 0.77 ^a (5.5 – 7.5)	7.1 ± 1.10 ^a (5.3 – 8.3)	8.0 ± 0.74 [§] (7.3 – 8.8)	7.7 ± 0.52 (7.2 – 8.6)	8.0 ± 0.77 (7.2 – 9.2)
Volume (cm ³)	147.5 ± 20.82 ^a (125.6 – 182.0)	179.1 ± 26.55 ^{a,b,§} (143.0 – 202.4)	238.0 ± 19.08 ^{b,c} (213.3 – 262.1)	292.4 ± 17.00 ^c (272.7 – 317.7)	270.9 ± 41.77 ^d (225.0 – 339.2)	288.7 ± 43.22 ^d (260.1 – 365.3)
Parenchymal density (HU)	45.2 ± 1.05 (44.6 – 47.1)	44.4 ± 5.53 (36.4 – 51.2)	35.9 ± 6.73 [§] (29.7 – 44.0)	34.6 ± 8.6 (23.6 – 46.2)	30.5 ± 3.50 (26.8 – 34.5)	30.1 ± 11.64 (21.5 – 48.6)
Ureteral diameter (cm)	0.3 ± 0.07 (0.2 – 0.4)	0.3 ± 0.05 (0.3 – 0.4)	0.4 ± 0.20 (0.3 – 0.7)	0.4 ± 0.24 (0.3 – 0.9)	0.6 ± 0.20 [§] (0.4 – 0.8)	0.7 ± 0.06 (0.6 – 0.8)

486

487 ^{a, b, c, d} Within rows measurements with identical indices are different (P < 0.05)

488 [§] First significant difference compared with examination 1 (P < 0.05)

489 *Table 3: CT measurements of the urinary bladder and urethra in five Holstein-Friesian bull calves during the first 105 days of life (mean ± sd,*
490 *median, range).*

Variable	Examination					
	1	2	3	4	5	6
Distance between apex of bladder and pelvic brim	6.5 ± 3.52 (4.0 – 12.6)	6.1 ± 1.97 (2.9 – 7.8)	7.3 ± 2.33 (5.0 – 10.5)	7.9 ± 4.0 (2.9 – 12.8)	6.4 ± 1.97* (4.3 – 8.2)	4.4 ± 0.35 ^{#,§} (4.2 – 4.7)
Urinary density (HU)	10.6 (7.4 – 39.2)	9.5 (5.6 – 15.6)	10.8 (-2.7 – 18.8)	7.5 (1.2 – 37.7)	20.0 (-3.0 – 30.2)	27.5 [#] (21.4 – 33.5)
Urethral diameter (cm)	1.5 ± 0.33 (1.1 – 1.9)	1.5 ± 0.27 (1.2 – 1.9)	1.4 ± 0.27 (1.1 – 1.8)	1.6 ± 0.16 (1.4 – 1.8)	1.5 ± 0.24 (1.1 – 1.7)	1.7 ± 0.24 [°] (1.5 – 2.0)

491

492 [°] Measured in 4 of 5 calves

493 ^{*} Measured in 3 of 5 calves

494 [#] Measured in 2 of 5 calves

495 *Table 4: CT measurements of the adrenal glands in five Holstein-Friesian bull calves during the first 105 days of life (mean $\pm$ sd, range, all*
496 *measurements in cm).*

Variable	Untersuchung					
	1	2	3	4	5	6
Length of right gland	1.27 $\pm$ 0.23 (0.89 – 1.45)	1.46 $\pm$ 0.46 (0.96 – 2.06)	1.47 $\pm$ 0.32 (1.18 – 1.95)	1.65 $\pm$ 0.26 [§] (1.30 – 1.96)	1.69 $\pm$ 0.38 [°] (1.26 – 2.04)	1.78 $\pm$ 0.31 (1.38 – 2.13)
Widht of right gland	0.77 $\pm$ 0.17 0.53 – 0.98	0.87 $\pm$ 0.34 0.58 – 1.44	0.85 $\pm$ 0.22 (0.49 – 1.10)	0.85 $\pm$ 0.22 (0.51 – 1.06)	0.89 $\pm$ 0.17 [§] (0.71 – 1.10)	0.92 $\pm$ 0.21 (0.68 – 1.18)
Length of left gland	1.01 $\pm$ 0.14 (0.88 – 1.23)	0.99 $\pm$ 0.28 (0.68 – 1.32)	1.33 $\pm$ 0.23 [§] (0.96 – 1.58)	1.42 $\pm$ 0.64 (0.90 – 2.46)	1.28 $\pm$ 0.22 ^{°, *} (0.98 – 1.53)	1.53 $\pm$ 0.21 (1.39 – 1.90)
Widht of left gland	0.66 $\pm$ 0.06 (0.59 – 0.75)	0.55 $\pm$ 0.13 ^a (0.36 – 0.69)	0.76 $\pm$ 0.17 ^a (0.55 – 1.02)	0.94 $\pm$ 0.33 (0.52 – 1.28)	0.74 $\pm$ 0.22 (0.51 – 0.98)	0.91 $\pm$ 0.15 [§] (0.77 – 1.13)

- 497
- 498 [°] Measured in 4 of 5 calves
- 499 ^a Measurements are different (P < 0.05)
- 500 [§] First significant difference compared with examination 1 (P < 0.05)
- 501 ^{*} Significant difference compared with right adrenal gland (P < 0.05)