수의학석사학위논문

개에서 Doppler 초음파를 이용한 Ureteral jet 현상의 평가

Evaluation of the Ureteral Jet Using Doppler Ultrasonography in Dogs

2015년 2월

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이 논문을 수의학석사학위논문으로 제출함

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오 현 정

오현정의 석사학위논문을 인준함

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Abstract

Evaluation of the Ureteral Jet Using Doppler Ultrasonography in Dogs

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The ureteral jet is the phenomenon caused by forceful ejection of urine from the vesicoureteral junction (VUJ) into the urinary bladder. This study was performed to identify distinct ureteral jets using color Doppler ultrasonography (US), to provide insight into ureteral obstruction and to contribute to the study of the urodynamics and function of the ureter in dogs. Color Doppler US was applied to detect urinary flow from the right ureteral orifice in eight healthy beagle dogs. Under anesthesia, 0.9% saline (2.5 ml/kg/h) and diuretic (furosemide, 0.5 mg/kg) were administered intravenously in order to detect a distinct ureteral jet. In addition, the frequency, velocity, duration and waveform of the ureteral jets were recorded. In eight of the eight dogs (100%), the ureteral jet was clearly visualized from 2 min to 5 min (mean, 3.57 min; SD, ±0.90 min) under diuresis and anesthesia. The measured frequency, mean peak velocity and mean duration of the right ureteral jet in seven dogs were 9.86±3.09 jets/min, 34.07±10.02 cm/s and 2.82±1.08 s, respectively. One dog was excluded from the examination because of the different direction of the right ureteral jet. Six patterns of ureteral jet waveform were identified in seven dogs. Moreover, during the period measured at 10 min from the point to 10 min after the initial jet, only three waveforms were identified. The results showed that Doppler US for ureteral jet could be potentially useful in assessing ureteral abnormalities, such as obstruction, ectopic ureter and function of the ureter in dogs.

Keywords : ureteral jet, ultrasonography, Doppler, obstruction, dogs

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Introduction

The term ureteral jet refers to the urine flow in which urine is ejected forcefully from the vesicoureteral junction into the urinary bladder. On two-dimensional (2-D) ultrasonography (US) imaging, urine ejects in the form of a low-intensity echogenic stream from the ureteral orifice. However, color Doppler US demonstrates this phenomenon far more clearly, and using a pulsed Doppler allows further characterization of the jet.[1-6] Many previous studies on humans have addressed issues, such as why the jet could be detected,[3, 4] the incidence of visualization of the jet and its frequency,[5] the velocity and duration of the jet,[2, 6, 7] symmetry of jets from the right and the left,[8] temporal fluctuation,[9] the effect of hydration on the jet,[10] clinical applications such as ureteric patency,[11] and the pattern of the Doppler waveform.[6, 9, 10, 12, 13] However, it may be more difficult to identify the ureteral jet on ultrasonographic examination in animals, such as dogs, because of many limitations, including the physical constraints of the patient, the locational difference in urinary specific gravity, and the degree of distention of the urinary bladder. Thus, in veterinary medicine, the results of studies on the ureteral jet phenomenon remain unclear. The first clinical application of the ureteral jet in dogs has been described, which suggested that the non-visualization of the ureteral jet might be helpful in diagnosing ectopic ureter.[14] Despite much controversy about the clinical utility of the ureteral jet in humans, the detection of urine jet flow has been considered a useful tool to evaluate urinary tract obstruction in which the presence of a ureteral jet could be used to exclude complete obstruction.[15-19] A functional sphincter with dual mode action at the human VUJ was proposed in previous studies of Doppler US of the ureteral jet.[12 13 20 21]

The primary purpose of this study is to describe the phenomenon of the ureteral jet in dogs under general anesthesia by using diuretics and subsequent Doppler ultrasonographic examination to determine whether ureteral jets could be visualized consistently enough to aid in the evaluation of ureteral obstruction and in urodynamic studies of the ureter. We hypothesize that an active VUJ sphincter with myogenic and neurogenic components functions in dogs as it does in humans.

Materials and Methods

Eight adult beagle dogs, including two females and six males (weight range, 7.8−13.5 kg; mean, 11.3 kg; SD ±1.90) were recruited for this study. CBC, serum biochemistry profiles, including BUN, creatinine, and electrolyte, and urinalysis, revealed no abnormalities.

Color Doppler ultrasonographic examination was performed using a commercially available unit (Aloka Prosound α7®, Hitachi Aloka Medical Ltd, Japan) with a 4–11 MHz linear transducer. The pulse–repetition frequency (PRF) was 5 kHz. Intravenous 0.9% saline was given to each dog at a rate of 2.5 ml/kg/h in order to provide sufficient hydration and to facilitate the identification of the ureteral jet. The urinary bladder was scanned in dorsal recumbency to assess the degree of distention. A real–time examination was performed in each dog when the urinary bladder was partially distended. Five mg/kg of Zoletil (Zoletil 50®, Virbac, France) was injected intravenously (IV), and an equal amount of anesthetic was injected into the antebrachial muscle region. Under anesthesia, the ureteral orifice of the right ureter was identified in a transverse image plane (Figure 1).

To obtain a clear image of the right ureteral orifice and jet, the probe was moved craniomedially, with the right orifice as the axis (Figure 2). Then 0.5 mg/kg of furosemide (Lasix Injection®, Handok Pharmaceuticals Co., Republic of Korea) was injected to detect the ureteral jet from the orifice. The orifice was observed until the ureteral jet was identified. After the color signals were detected, the initial time and frequency were recorded. The scan axis was rotated to the axis of the jet, and spectral waveforms were obtained as close as possible to the right orifice. Between jets, the Doppler cursor was carefully maintained directly over the ureteral orifice. Even a slight

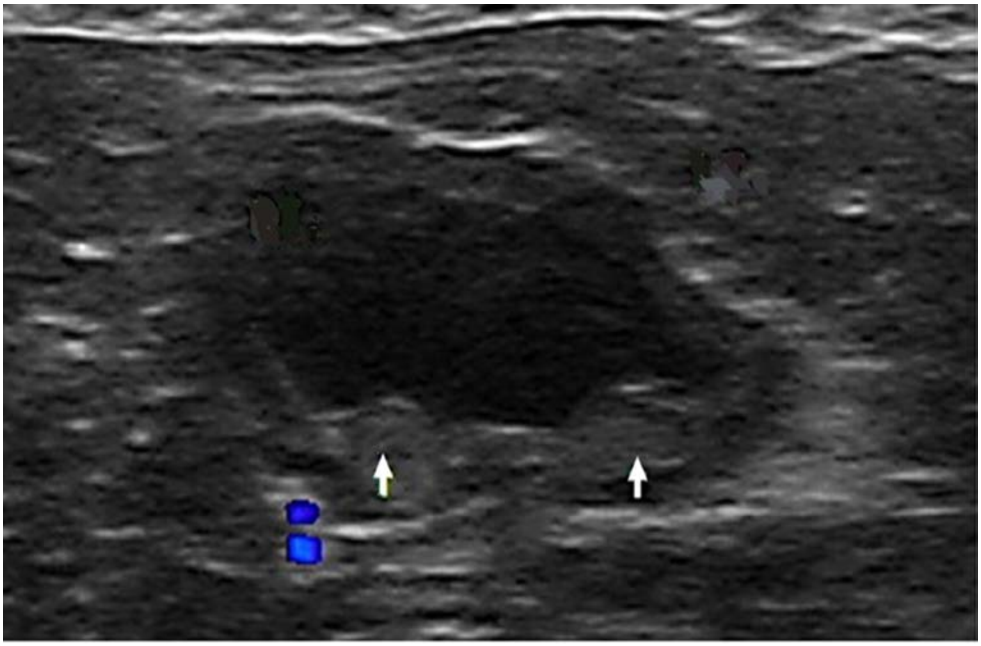

Figure 1. Transverse ultrasound image of the urinary bladder showing two small elevations of the mucosal surface, representing the ureteral orifices (arrows) on the dorsal aspect.

displacement of the cursor from the center of the jet led to poor spectral waveforms, which were rejected. In dogs in which the jets were perpendicular to the bladder base, scanning had to be done from a lateral position in order to obtain a valid Doppler angle showing spectral waveforms.

Receiver gain and output were altered to optimize visualization. The Doppler gate was opened wide enough to include the entire jet, and it was centered at the point of maximum flow. The Doppler angle was set parallel to the streamline in the center of the jet and limited within the range of 30° to 60°, as far as it was possible. Real-time

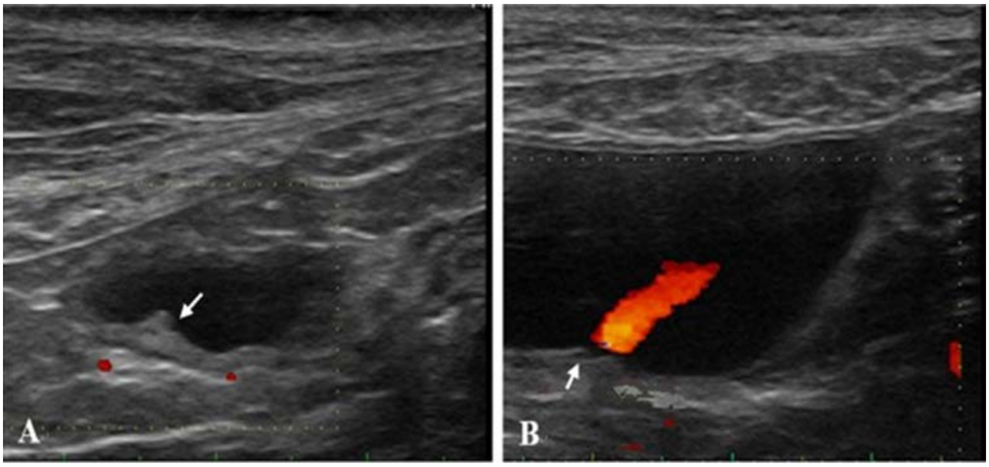

Figure 2. Oblique ultrasound image of the urinary bladder showing clearly the orifice (A) and the jet flow (B). The anechoic area within the elevation represents the right ureter (arrow).

color Doppler US and spectral waveforms were recoded for 40 to 60 min (Figure 3). When a jet was not identified, the examination ended before 40 min, and a urinary bladder height was measured on the transverse scan. The features of the jet flow were measured by the pulsed Doppler system, and the waveform was obtained by Doppler wave spectral analysis (Figure 4). The frequency, duration time, velocity and waveform of the ureteral jets were measured during the period when they occurred the most actively (i.e., the period measured for 10 min from the point 10 min after the initial jet) (Figure 3). The waveform was categorized according to the human waveform system of classifying ureteral jets.

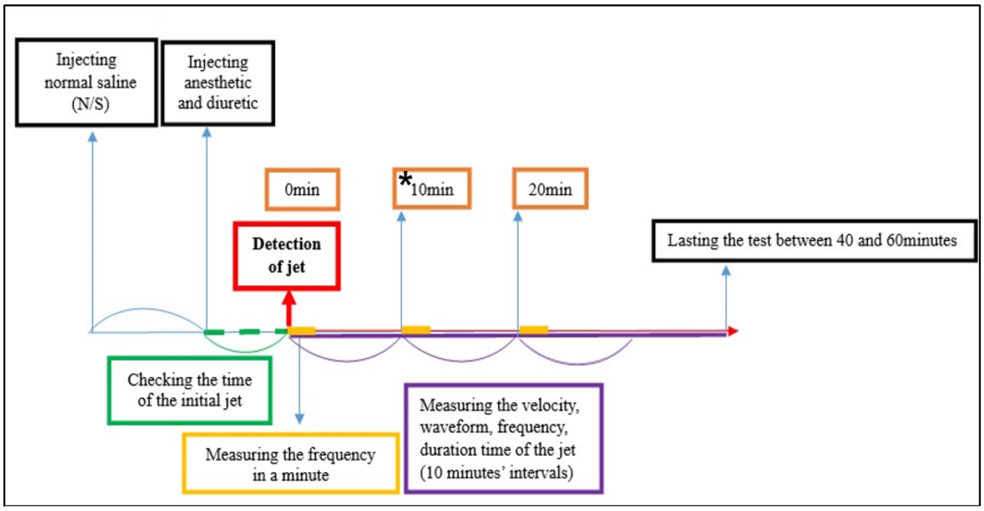

Figure 3. Schematic diagram of the experimental procedure

Note: * = The section in which the jet is identified most distinctively

Figure 4. Spectral Doppler image of the right ureteral orifice (a = the point of commencement of the Doppler signal, b = termination, c = peak velocity, T = duration time, V = velocity). The peak velocity (c) is measured to approximately 47.8 cm/s and the duration time (T) is 2.0 s. The waveform is monophasic.

Results

1. *Detection of the ureteral jet*

Ureteral jets were detected by color Doppler US in all eight dogs (100%). The left and right VUJ were visible as two protuberances on the mucous layer when a probe was moved from the urethra to the bladder neck on transverse scan (Figure 1). At irregular intervals, a burst of color flows was observed to emanate from one or both of the ureteral orifices, which commonly occurred separately but occasionally occurred in concert. On the oblique scan, the probe was moved craniomedially, with right orifice as the axis, and the right ureteral orifice was identified clearly as a mucosal elevation. The right ureter was shown as an anechoic area within the bulging structure on the mucosal surface (Figure 2A). The flow toward the transducer was assigned a red color (Figure 2B). The oblique scan image was chosen for the optimal depiction of jets from the right side, and it did not interfere with the other side.

2. *Direction of the ureteral jet*

In seven of eight dogs (7/8), the ureteral jets were cranial or craniomedial (Figure 2B). They sometimes were perpendicular to the mucosal layer, which was quite similar to that shown in human studies.[6, 8, 9, 11, 22, 23] One dog was excluded from the spectral Doppler study because the jet flow direction was different, and it therefore was color−coded as blue.

3. *Initial time of the ureteral jet*

The initial time of the jet ranged from 2 to 5 min (mean, 3.57 min; SD, ±0.90 min). The results for each dog are listed in Table 1, and the mean initial times are shown in Figure 5. This phenomenon was clearly detected within 5 min in all dogs.

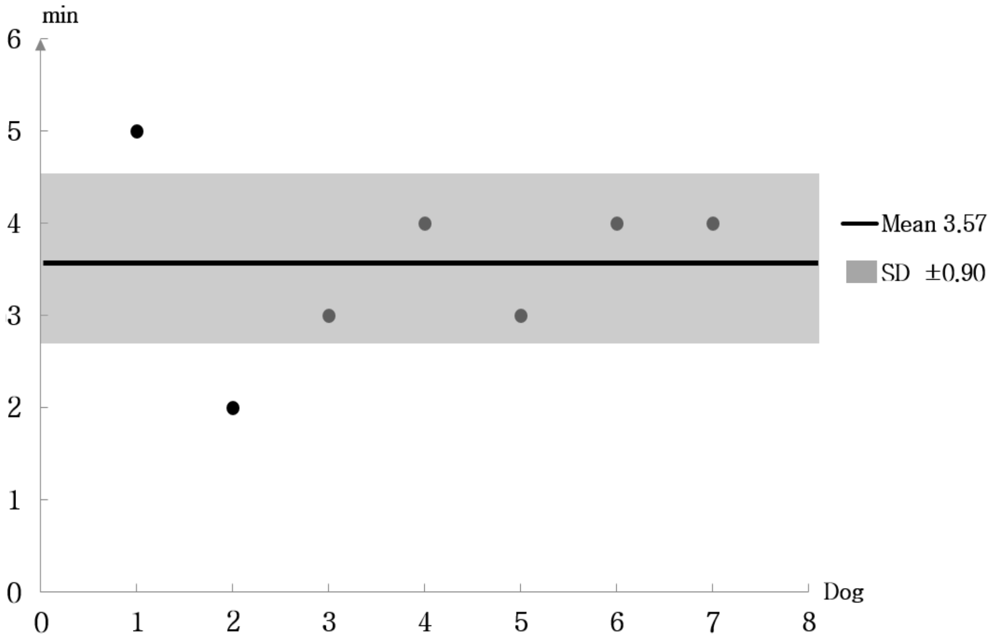

Figure 5. The mean and standard deviation (SD) of the initial time. Note that the jet phenomenon occurred in every dog within 5 min of the injection of the diuretic.

4. *Doppler waveforms of the ureteral jet*

When the range-gated Doppler device was arranged to a sample volume that coincided with the area of the trigone, craniomedial to the ureteral orifice, various Doppler signals were achieved (Figure 4). The results obtained from each dog are shown in Tables 1 and 2.

Six patterns of ureteral jet waveform could be identified, based on previous studies on humans. These waveforms were divided into six patterns according to the number of the peaks within a single ureteral jet: monophasic (only one peak), biphasic (two peaks), triphasic (three peaks), polyphasic (four or more peaks), square (a plateau type with no distinct peak, but within the average duration), and continuous (waveform has an irregular plateau or no peak with duration longer than means duration)(Figure 6).[12, 13] During the period when the ureteral jets occurred most actively, that is, at a point 10 min after the initial jet, only three waveforms were identified. Of seven dogs, three dogs (42.9%) were continuous, another three dogs (42.9%) were square and one dog (14.2%) was monophasic (Table 1).

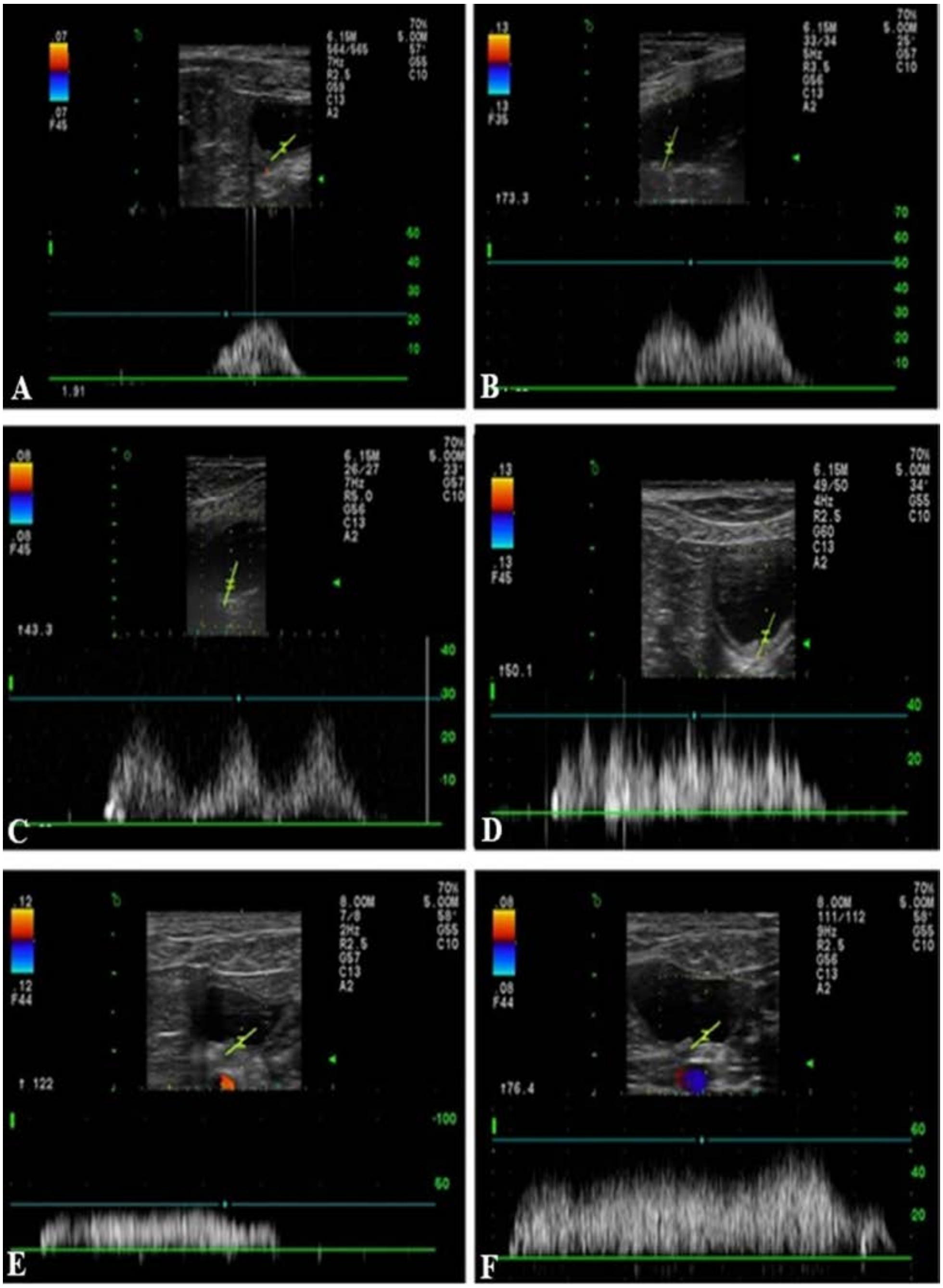

Figure 6. The six patterns of the ureteral jet. (A) monophasic; (B) biphasic; (C) triphasic; (D) polyphasic; (E) square; (F) continuous

Table 1. The parameters of ureteral jets detected during the period measured for 10 min from a point 10 min after the initial jet.

Dog number	Initial time (min)	frequency (jets/min)	†Average peak velocity (cm/s)	†Average duration (s)	waveform
1	5	6	20.37 (±3.17)	4.21 (±0.67)	Continuous
2	2	9	33.66 (±3.86)	2.18 (±0.22)	Square
3	3	9	55.57 (±2.61)	2.57 (±0.08)	Square
4	4	8	29.26 (±0.64)	1.81 (±0.04)	Square
5	3	8	31.56 (±1.93)	3.15 (±0.25)	Continuous
6	4	15	30.66 (±2.98)	1.37 (±0.13)	Monophasic
7	4	14	36.66 (±2.21)	4.15 (±0.21)	Continuous

Note: †: values are given as mean plus or minus standard deviation.

Table 2. Changes in parameters over time in each dog and the height of bladder when the jet disappeared (v = velocity, f = frequency, d = duration)

Dog number	Time (min)	Frequency (jets/min)	Change in the appearance of the jet	Height of bladder (cm)	Change of parameters (v, *f*, d)
1	60	4	No change in the appearance	–	reduced *f*
2	60	8	Disappeared jet flow but shown as red dot signals	5.12	reduced v, *f*, d
3	30	5	Absence of jet (at 40 min)	5.83	reduced *f*, d
4	60	8	Disappeared jet flow but shown as red dot signals	4.41	reduced v, d
5	50	7	Disappeared jet flow but shown as red dot signals	5.79	reduced v, *f*, d
6	50	8	No change in the appearance	–	reduced v, *f*, d
7	30	10	Absence of jet (at 40 min)	5.27	reduced v, *f*, d

5. *Duration of the ureteral jet*

The measured duration of individual jets varied from 1.19 s to 4.86 s. The average duration in all seven dogs ranged from 1.81 s to 4.41 s; the mean value of average duration was 2.82 s (SD, ±1.08 s). The results obtained from each dog are shown in Table 1. The average and standard deviation of the duration and mean value of average duration in each dog are plotted in Figure 7.

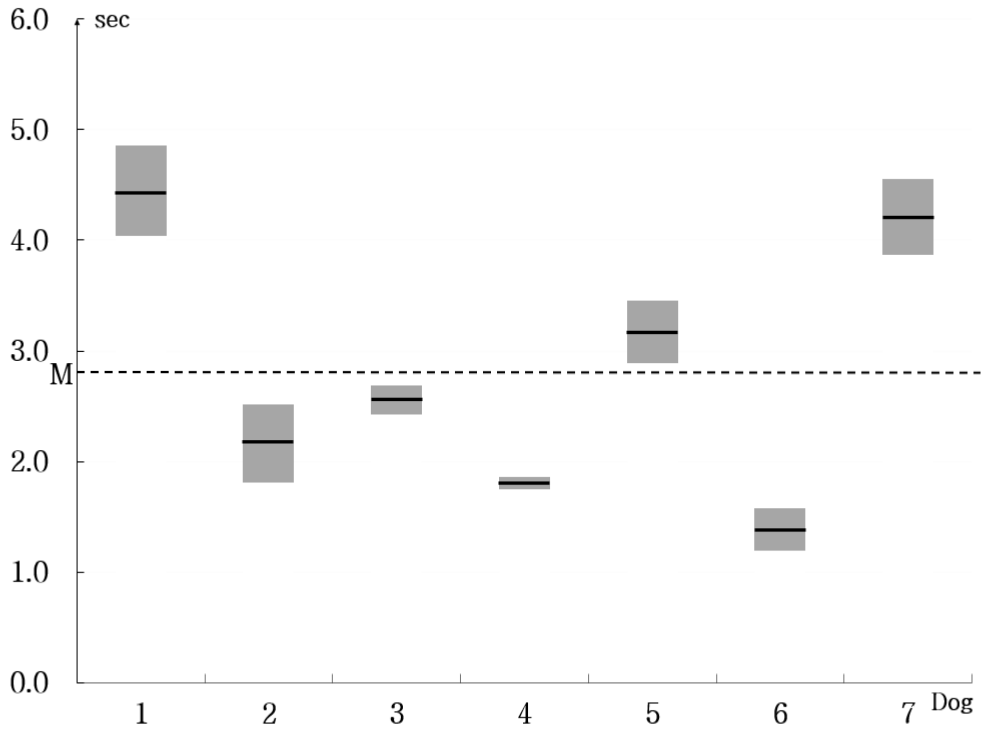

Figure 7. The average and standard deviation of the duration and the mean value of the average duration in each dog (M = the mean value of the average duration.)

In six of the seven dogs (6/7), the average duration decreased over time. In three of the six dogs (3/6), a red color−coded ureteral jet was not visible, but a red spot was identified at the orifice region. The complete absence of a color signal was identified in two of the six dogs (2/6) (Table 1). The Doppler waveform of the red color coded spots was a very short monophasic waveform with duration reduced to fractions of a second (Figure 8D). Only one of seven dogs (1/7) had a consistent jet without any change in duration, but the frequency decreased (Table 1). Five dogs (5/7), whose ureteral jets either

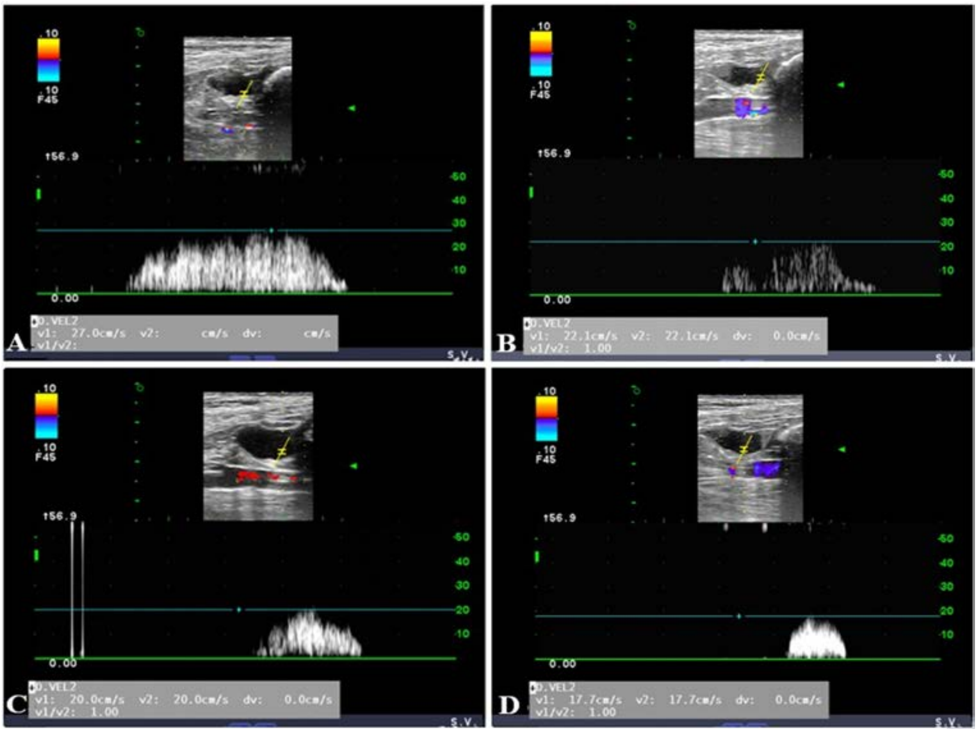

Figure 8. Change in spectral Doppler image throughout the examination in dog 5. Over time, this dog showed decreased peak velocity and duration. (A) 10 min; (B) 30 min; (C) 40 min; (D) 60 min

disappeared or were shown as red color−coded spots at the orifice region, had significantly distended bladders, the mean height of which was 5.28 cm (SD, ±0.52 cm) in the transverse plane. The results are shown in Table 2.

6. *Peak velocity of the ureteral jet*

The measured peak velocity of the individual jets varied from 15.30 cm/s to 60.60 cm/s. The average peak velocities in seven dogs ranged from 20.37 to 55.37 cm/s; the mean values of average peak velocities was 34.07 cm/s (SD, ±10.02 cm/s) (Figure 9). Five of seven dogs (5/7) showed a decrease in peak velocity over time. In four dogs (4/5), the decrease in duration was usually accompanied by a decrease in peak velocity (Table 2).

7. *Frequency of the ureteral jet*

The frequency of jets ranged from 6 to 15 jets/min in seven dogs (mean, 9.86 jets/min; SD, ±3.09 jets /min) (Table 1). Over time, the number of jet occurrences was reduced in six of seven dogs (6/7). Over time, seven dogs showed a decrease in at least one of the jet parameters, such as peak velocity, duration, frequency (Table 2).

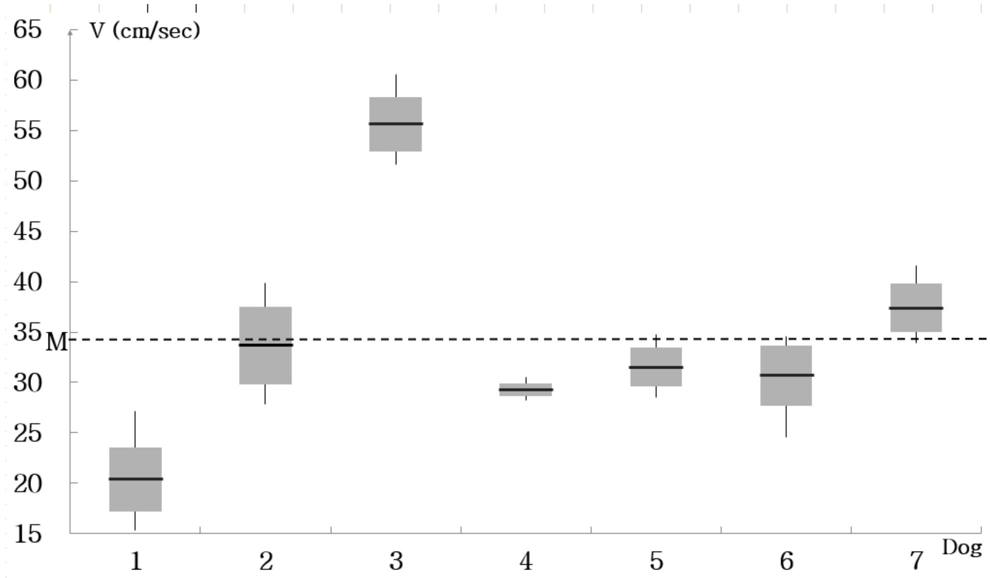

Figure 9. The average peak velocity and the mean value of the average peak velocity in seven dogs. (M = the mean value of the average peak velocity.)

Discussion

Ureteral jets were detected by color Doppler US in all eight dogs. Despite the small number of dogs, the results of this study showed that color Doppler US allowed the simple and safe visualization of ureteral jets. Using color Doppler US, the ureteral jet was clearly visualized as a red flow. Hence, the detection rate was high because of the clear identification.

The ureteral jet is a phenomenon caused by the forceful ejection of urine into the bladder lumen by the peristaltic contraction of the ureter.[2, 12] When the bolus of urine being transmitted through the ureter reaches the terminal portion, it is ejected forcefully into the bladder through the VUJ.[12 13 24] The US image of the jet has been consistently observed in both humans and dogs.[1, 6, 13 14] It can be detected by the gray scale as a stream or burst of low-intensity echoes emerging from the ureteral orifice.[13 20] The jet lasts for only a few seconds, but it is fast enough to produce a frequency shift; thus, both color and Doppler waveform can be obtained in real time.[20] The ureteral jet can be further characterized by its pulsed Doppler waveform, which is related to renal or ureteral functions.[2, 20]

However, this phenomenon is not always detected in humans and dogs; it seems to occur only when certain requirements are met. A difference in urinary specific gravity between the ureter and bladder, appropriated hydration, and the state of bladder filling were shown to be required.[1, 5, 14, 25, 26] Unlike humans, dogs cannot control their fluid intake and urination. However, it is difficult to examine the ureteral jet of dogs in their natural conditions. Therefore, a method is required to measure the ureteral jet consistently in order to make better use of the results of the research related to this phenomenon and apply them to clinical practice in veterinary medical science. It was reported that contrast medium and sterile saline were injected into the bladder of dogs in order to detect a constant jet,[14] but in our experiment, a consistently distinctive ureteral jet flow was detected within five min by using only intravenous hydration with 0.9% saline and a diuretic (Figures 2 and 5). In the present study, without controlling the difference in urinary specific gravity between the bladder and the ureter before the examination, ureteral jets could be identified in all eight dogs.

Previous studies on both US and magnetic resonance imaging found that the ureteral jet is usually directed either cranially or craniomedially, with or without crossing of the jets.[1, 13, 27] Other studies showed that ureteral jets were directed in a vertical direction or perpendicular to the bladder base. [6, 8, 9, 11, 22, 23] The results we obtained using color Doppler US in seven dogs are similar to those in previous studies of humans. However, in one dog, the jet went in a different direction, and it was color-coded as blue. It was previously reported that a change in direction was associated with internal and external influences, such as ureterocele, a full bladder, or an enlarged rectum and prostate, which causes distortion in the bladder in humans.[8, 28, 29] After performing excretory urography and computed tomography in this dog, the locations of ureterovesicular junctions on both sides were asymmetrical, with a distended bladder and enlarged rectum. We assumed that the factors that caused the distorted bladder and VUJ could affect the direction of the ureteral jet, as in humans, but further studies are needed to assess this effect in dogs.

The US has been reported as an accurate and noninvasive method for evaluating the renal collecting system, and it is commonly used in cases of suspected renal obstruction.[16,19,30-37] Although gray-scale US provides important anatomic information, it cannot differentiate between obstructive and non-obstructive dilatation of the renal collecting system.[16, 30, 32, 34, 38-41] Contemporary use of pulsed and color Doppler US has enabled the evaluation of the function and obstruction of the kidney and ureter.[42] It was previously suggested that the presence of jet could be used to exclude complete ureteral obstruction, and the complete absence of jet is symptomatic of the high-grade obstruction caused by ureteral calculi in humans.[8, 10, 15, 20, 27, 38-41, 43] Complete obstruction can reliably be ascertained by the absence of a ureteral jet on the suspected side of obstruction, with very high sensitivity and specificity.[42] The present study showed that ureteral jet could be consistently visualized in dogs using a simple technique, which suggests that the non-visualization of the ureteral jet could possibly be used as a diagnostic tool to determine obstruction of the ureter as in humans.

In the experiment, the observation of the jets became more difficult over time, and five dogs lost their jets completely. In a subsequent Doppler US study, a markedly distended bladder was demonstrated, so it was no longer possible to detect ureteral jets or to record Doppler signals from the ureteral orifices in these dogs. It is assumed that based upon previous reports and our experiments, several factors could have affected the results, including a reduced difference in urinary specific gravity between the bladder and the ureter, an excessive distention of the bladder and a reduction in the efficacy of the diuretic.[1, 5, 14, 25, 26] In particular, when the urinary bladder is completely filled, it is possible that pressure by the distended bladder on the ureters prevents the jet−like entry of urine into the bladder.[1] Even though the urinary specific gravity between the ureter and bladder was not controlled in this study, in order to detect the ureteral jets, it is necessary to control the size of the bladder if it is not too distended, as in the previous US Doppler studies.

The results of the present study showed that there are various ureteral jet waveform patterns in dogs, as in humans (Figure 6). In humans, six patterns have been identified according to the number of peaks within a particular Doppler waveform: monophasic, biphasic, triphasic, polyphsic, square and continous.[12, 13, 20] These waveforms were further classified into three categories: 1) monophasic jet is classified as the first category of a simple and immature pattern; 2) bi−, tri− and polyphasic patterns are classified as complex and mature patterns; 3) square and continuous forms are classified as the diuretic pattern and these modified waveforms represent under the state of forced diuresis.[12, 20] It was explained that the reason for the change in the waveform patterns of the ultimate ureteral jet were caused by the modification of jet by an active sphincter mechanism at the human VUJ.[12, 13, 20] There are two components in the dual mode action of the functional sphincter: the myogenic (primary or immature) and the neurogenic (secondary or mature). The monophasic jet pattern is the result of contraction caused by the myogenic component of the VUJ, while the complex pattern is the result of the modulation of the myogenic component of the jet by the neurogenic component, in response to distal intra−ureteral pressure.[13 20 44] The subsequent ureteral jet waveform varies depending upon whether the neurogenic component is active or not.[12, 20, 44] Based on the results of previous studies and the findings of this study, we postulate that the dog's VUJ can act as a functional sphincter with myogenic and neurogenic components, as in humans.

The results of this study showed a significant drop in the incidence of the complex pattern at a point 10 min after the initial jet, in which the jet was identified the most distinctively. Only three patterns (monophasic, continuous and square waveforms) were observed (Table 1) in this period. In humans, when only the myogenic component is functioning (as in a small immature subject), under general anesthesia or in certain pathological conditions, the jet pattern reverses to the monophasic pattern.[13] It has already been established that in humans, continuous or square waveforms represent modified waveforms under the state of forced diuresis. Premature relaxation of the VUJ is likely to be governed by the neural mechanism observed in forced diuresis.[6, 9, 12, 13] Only three patterns were identified in this period, which is considered that the anesthetic and diuretic could be affected the VUJ mechanism. In dogs undergoing unusual physiological conditions, such as general anesthesia and significant diuresis stress, the VUJ mechanism may be altered, and a modified ureteral jet pattern is observed. This study could not be designed to identify a particular drug or drugs that would cause this change. However, because of the change in the ureteral jet Doppler waveform to monophasic, continuous and square patterns, it is assumed that the anesthetic and diuretic were influential factors. The observation of a pharmacological effect on the VUJ supports the hypothesis that an active VUJ sphincter with myogenic and neurogenic components functions in dogs, as it does in humans. Further studies may be necessary to determine the correlation between the function of VUJ and the change in the jet pattern and to evaluate the clinical significance of Doppler waveforms in dogs.

In humans, under the condition of forced diuresis, the jet has a higher velocity, duration and frequency than in the normal physiological state.[2] In this study, the dogs were given a diuretic and 0.9% saline intravenously (IV) during the examination. The Doppler waveforms represented under the state of forced diuresis in humans have also been identified. Based on previous studies and our experiment, it can be assumed that the results of velocity, duration and frequency in this study would be higher than in dogs in a normal physiological state.

It was previously reported that urinary volume is obtained from the mean velocity, duration, area of the ureteral orifice and frequency, using the formulas in humans.[2] Although the area of the ureteral orifice was not measured in this study, a decrease in mean peak velocity, duration or frequency was identified in seven dogs over time, which was shown clearly on the Spectral Doppler image (Figure 7 and Table 2). Based on previous studies and our results, the urinary volume was reduced over time in every dog, and the parameters measured by pulsed Doppler could be used to estimate urinary volume in dogs, especially when the insertion of a urethral catheter is difficult.

This study has several limitations. The relatively small number of dogs included in the study and the absence of values of a normal physiological condition limited the power of the statistical results. In addition, the application of the Doppler imaging technique requires technical expertise and high-quality equipment for high accuracy. However, the jet phenomenon of urine propelled from the ureteral orifice was detected clearly by color Doppler US. The detection of consistent ureteral jet can be used in the assessment of ureteral abnormalities, such as obstruction and ectopic ureter. Further studies may be warranted to evaluate the clinical relevance of the phenomenon of the ureteral jet in dogs.

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국문 초록

Ureteral jet은 vesicoureteral junction을 통해 요관에서 방광으로 요가 분출될 때 나타나는 현상이다.

이 연구는 간단한 처치 및 color Doppler 초음파를 이용하여 개에서 확인하기 어려웠던 ureteral jet 현상을 간단하고 신속하게 관측할 수 있는 방법 및 지속적인 현상 확인을 통해 비침습적으로 요관 폐색 및 요관의 기능적 평가의 이용 가능성에 대해 조사하였다.

8마리의 건강한 비글견의 우측 요관에서 발생하는 ureteral jet 현상을 Color Doppler 초음파를 이용하여 확인하였다. 모든 개체는 충분한 수화상태를 유지하기 위해 0.9% saline을 2.5 ml/kg/h의 속도로 주입하였으며, 보다 용이하게 ureteral jet 현상을 확인하기 위하여 마취상태에서 이뇨제 주입이 이뤄졌다. 확인된 jet은 pulsed Doppler 초음파를 이용하여 jet의 속도, 빈도수, duration, 파형의 분석이 이뤄졌다. 모든 개체에서 ureteral jet현상이 5분 이내 발생하는 것을 뚜렷이 확인할 수 있었다. 다른 방향의 jet이 확인된 한 마리 개체를 제외한 7마리 개체에서 Doppler 초음파를 이용한 jet의 분석이 이뤄졌다. 가장 뚜렷하게 jet이 관측되는 구간(jet 발생 후 10분째)에서 확인된 jet의 빈도수, 평균 peak속도 그리고 평균 duration은 각각 9.86±3.09 jets/min, 34.07±10.02 cm/s, 2.82±1.08 s으로 측정되었다.

결론적으로 이 연구는 간단한 처치 및 Doppler 초음파를 이용하여 ureteral jet 현상을 명확히 확인하고, 이를 통해 요관의 폐색, 이소성

요관과 같은 요관이상 및 요관의 기능적 변화 평가와 관련한 다양한 연구에 적용 가능할 것으로 판단된다.

주요어 : ureteral jet, 초음파, Doppler, 폐색, 개

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