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Abstract

Doppler ultrasound measures of testicular blood flow in stallions

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1. Introduction

In human medicine, Doppler ultrasonography has become a valuable tool for identifying testicular pathology associated with altered blood flow. This technique appears to be useful in diagnosing early inflammatory or neoplastic changes of testes and epididymides in men as well as in evaluating other scrotal disorders [1,2]. The characteristic pulse Doppler waveforms of the testicular artery at various locations in men have been described and reference values of the measures of blood flow in this vessel have been reported [3]. To date, similar work in horses has not been reported. Therefore, our objective was to evaluate the possibility of using Doppler ultrasonography to characterize blood flow to the stallion testicle. An additional objective was to compare testicular blood flow measures done with and without the stallion sedated.

2. Materials and methods

Three pony and four horse stallions, aged 5–31 years, were examined first without sedation, and again with xylazine sedation (0.5 mg/kg, i.v.). Each testis was evaluated using pulsed-wave, gray-scale Doppler ultrasound with a linear array 10 MHz transducer (Impact VFI, Universal Imaging, Bedford Hills, NY). The largest observable section of the artery in each of three locations (spermatic cord, proximal portion of testicular artery on epididymal edge of testis, and distal portion of testicular artery on free edge of testis) was identified on real-time scans and pulse Doppler analysis was performed and videotaped for subsequent calculations. Using the built-in spectral analysis algorithm, Peak Systolic Velocity, End Diastolic Velocity, Resistive Index [(Peak Systolic Velocity) – (End Diastolic Velocity)/(Peak Systolic Velocity)], and Pulsatility Index [(maximum velocity)

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– (minimum velocity)/(mean velocity)] were calculated for each of three sweeps at each location. Each set of three sweeps was averaged to obtain a single value. Comparison of measures with and without sedation, and of left and right testicles were done using dependent *t*-tests. For End Diastolic Velocity and Resistive Index, log transformations were required to normalize the distributions.

3. Results

Table 1 summarizes measurements obtained for six stallions. The left spermatic cord of one Standardbred stallion was rotated 180° at the time of examination, and so that stallion's data were omitted. For the cord location, mean End Diastolic Velocity was higher with sedation than without sedation ($P < 0.05$, dependent *t*-test). For the proximal and distal portions of the artery, trends for higher End Diastolic Velocity with sedation were observed. At all three locations of the testicular artery, Peak Systolic Velocity, Resistive Index, and Pulsatility Index were similar with and without sedation ($P > 0.05$, dependent *t*-test). Peak Systolic Velocity generally decreased as the artery coursed from the spermatic cord to the distal artery.

Measures for the left and right testicular artery were similar ($P > 0.10$, dependent *t*-test). Blood flow measures of ponies and horses appeared similar. Only one stallion had a lateral branch of testicular artery, running on the lateral surface of the right testis. Measures of blood flow in this vessel were similar to those of the proximal artery running along the epididymal edge of the testis. Occasionally, images of small, intra-testicular arteries were identified, but were too small to measure blood flow with the equipment used. For the testicle with the 180° torsion of the spermatic cord, the pulsed-wave Doppler pattern was

Table 1
Blood flow measures of testicular arteries of six stallions, unsedated and sedated

		Unsedated ($n = 12$ testes)			Sedated ($n = 12$ testes)		
		Mean	Range	S.E.	Mean	Range	S.E.
Cord	PS (cm/s)	32.20	23–43.3	1.70	34.1	22–50	2.40
	ED (cm/s)	0.80[a]	0–6	0.50	4.39[b]	0–8.3	0.80
	RI	0.97	0.72–1	0.02	0.86	0.6–1	0.03
	PI	4.10	1.9–6.2	0.40	3.70	2.4–5.4	0.29
Proximal	PS (cm/s)	22.40	11–31	1.90	24.50	15–40	1.99
	ED (cm/s)	1.80	0–5.3	0.60	3.08	0–7.7	0.69
	RI	0.91	0.66–1	0.03	0.87	0.73–1	0.20
	PI	3.22	1.5–5.2	0.29	2.93	2–4	0.18
Distal	PS (cm/s)	17.90	8.5–36	2.40	19.40	14–26	1.13
	ED (cm/s)	2.02	0–5.3	0.64	2.70	0.3–5.7	0.48
	RI	0.90	0.74–1	0.03	0.87	0.8–0.99	0.02
	PI	3.20	1.5–4.9	0.42	2.78	1.9–3.9	0.20

PS: Peak Systolic Velocity; ED: End Diastolic Velocity; RI: Resistive Index [RI = (PS – ED)/PS]; PI: Pulsatility Index [PI = (maximum velocity) – (minimum velocity)/(mean velocity)].
Values with different superscripts differ ($P < 0.05$), dependent *t*-test.

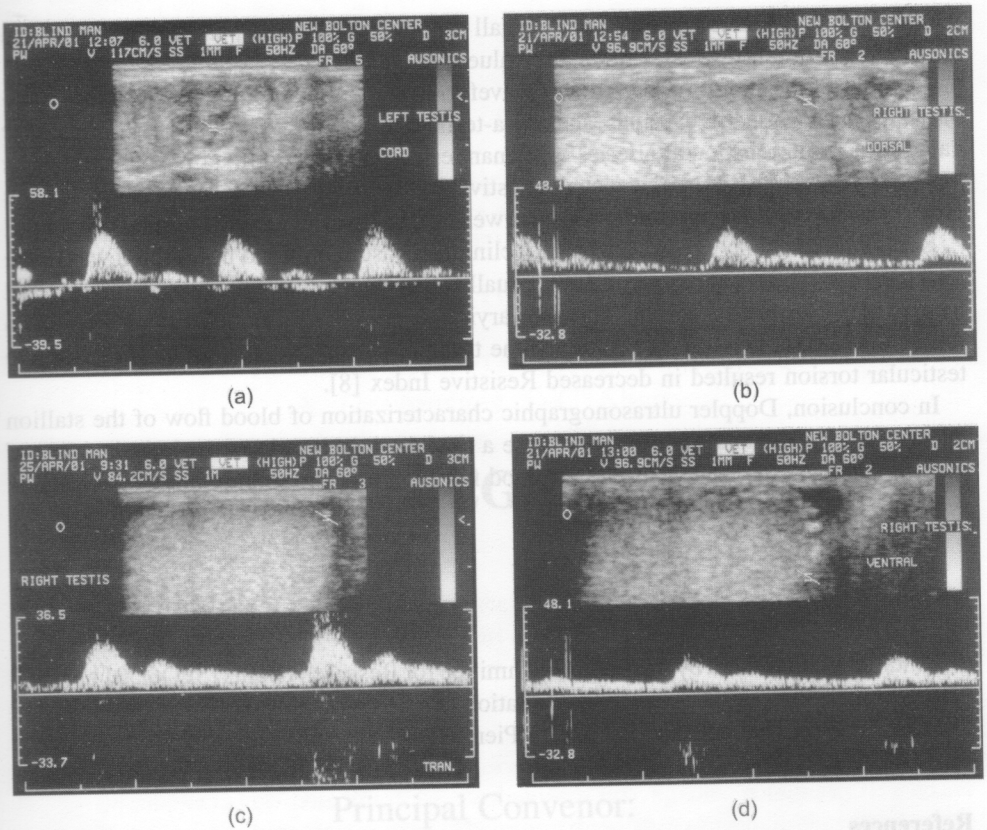

Fig. 1. Pulsed Doppler waveforms of a stallion testicular artery at the (a) spermatic cord, (b) proximal location, (c) proximal location with sedation, and (d) distal location.

indistinguishable from that of the other testicles. Blood flow measures were also similar to those of normal testicles. However, it seemed more difficult to locate consistent shapes of waveforms. Fig. 1 includes waveforms characterizing blood flow in the testicular artery of a stallion at the three locations evaluated, and at the proximal location during xylazine sedation. The waveforms appeared to be quite similar among the three locations. Individual differences between stallions in the shape of the systolic fragment of waveforms were only slight. However, waveforms from the testes during sedation were consistently judged as appearing "thicker" than without sedation.

4. Discussion

Obtaining ultrasound images of the testicular artery in various locations and performing spectral analysis was possible in stallions, although it required patience and knowledge of the angioarchitecture. Vascular cast models prepared earlier [4] were judged helpful. The

measurements obtained, though from a small sample of horse and pony stallions, may be useful as preliminary general reference values.

As reported in men [3], the velocity waveforms of supra-testicular arteries were more variable than those of capsular and intra-testicular arteries. The Resistive Index for capsular and intra-testicular arteries of human testes were smaller than in supra-testicular arteries. In these stallions the mean Resistive Index in all three locations was similar. However, due to equipment limitations, we were unable to evaluate intra-testicular arteries.

Resistive Index may be the most useful clinical measure of blood flow to and within the testis and epididymis. Resistive Index is usually altered by inflammatory processes [5] and by aging [6]. Surprisingly, in the dog [7], varying degrees of spermatic cord torsion had no measurable effect on Resistive Index of the testicular artery, while in rats a high degree testicular torsion resulted in decreased Resistive Index [8].

In conclusion, Doppler ultrasonographic characterization of blood flow of the stallion testicle is possible, and will likely become a useful clinical tool, particularly in cases of various scrotal disorders. Measures of blood flow can be expected to be similar with and without sedation of the stallion.

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