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Blood Perfusion of the Male Genital Organs – An Experimental Study in the Rat

L. Gatenbeck[1], B. Johansson[1] and L. Strömberg[2]

[1] Department of Urology, Danderyd Hospital, Danderyd and
[2] Departments of General and Experimental Surgery, The Karolinska Hospital, Stockholm, Sweden

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Summary. Male genital blood flow and its regulation have not been fully clarified. In the present study we employed a radioactive microsphere technique to estimate the blood flow simultaneously in the major urogenital organs of male rats. The recorded genital flow rates varied among the rats. The relative blood perfusion rates of the testicles, seminal vesicles and kidneys did not differ from one animal to another. However, the blood flow in the prostate gland was not correlated to the perfusion of any of the other investigated urogenital organs.

Key words: Blood flow, Male genital organs, Radioactive microsphere technique, Experimental study.

Introduction

The blood flow through the male genital organs and its regulation have not yet been fully clarified. Investigators have previously measured the blood flow in the genital organs of animals by isotope-clearance, indicator fraction and radioactive microsphere techniques [2, 4, 5, 7, 8, 21, 22, 24]. Discordant results have, however, been reported.

The radioactive microsphere technique, first described by Rudolph and Heyman in 1967 [18, 19], is now a well-established tool for experimental measurements of blood flow in organs and tissues of animals. The method has proved to be precise and to yield reproducible results [3, 5, 9, 15, 20].

However, only a limited number of studies have been reported where the blood flow in the male genital organs was measured by the radioactive microsphere technique [4, 5, 7, 8, 21].

The rat has frequently been used for studies on the physiology and pathophysiology of the male genital organs. Additional data about blood flow in the genital organs would enable better understanding of the regulation of their functions and it would help in evaluating and designing diagnostic and therapeutic procedures.

The purpose of the present study was, by means of the radioactive microsphere method, to measure the blood flow simultaneously in the major genital organs in male rats under standard experimental conditions.

Material and Methods

Fourteen male Sprague-Dawley rats (bred by Anticimex, Sollentuna, Sweden), weighing approximately 350 g each, were kept in animal cages at the Department under standard conditions for a minimum of one week prior to the experiments. The animals had free access to water and food.

Analgesia was induced with an intramuscular injection of 0.3 ml Hypernorm® (Leo, Helsingborg, Sweden) and an intraperitoneal injection of 0.05 ml Valium® (Roche, Basel, Switzerland). After weighing, the rat was placed on a pad with a warming lamp close to the chest to maintain the body temperature. After 15 min the rat was placed on its back with the extremities fixed to the pad. Free airway was secured by a tracheostomy. The left femoral artery and the right carotid artery were dissected free and a PE-50 polyethylene catheter (Portex Ltd, Hythe, Kent, England) was inserted into each of the two arteries. The catheter inserted into the femoral artery was connected to a blood pressure transducer (Type 746, Siemens-Elema AB, Stockholm, Sweden). The mean arterial blood pressure was continuously monitored and recordings were made with a polygraph (Grass model 7, Grass Instrument Co, Quincy, Mass., USA). Blood samples were collected via the same catheter.

Blood flow was determined by means of the radioactive microsphere technique described by Rudolph and Heymann [18, 19]. The microspheres were injected through the catheter into the right carotid artery. The catheter tip was on a level with the aortic root. A specially designed polyethylene catheter with a narrow distal end was introduced into the freed right femoral artery. The catheter was connected to a suction pump (model 352, Sage Instrument Ltd, Cambridge, Mass., USA). All inserted catheters were prefilled with a mixture of saline and Heparin® (Kabi, Stockholm, Sweden) 5,000 IE/ml. The rat was left to rest for 30 min before the measurement procedures were started.

Carbonized microspheres (3M Tracer Microspheres®, 3M Company, St. Paul, Minnesota, USA) were used for measuring blood flow.

Table 1. Blood perfusion of the genital organs of 14 male rats measured by means of radioactive microsphere technique and concomitant measured values for cardiac output and mean arterial blood pressure and their respective means and standard deviations

Rat no	Organ blood flow (ml/100 g organ tissue/min)						Cardiac output (ml/100 g bw/min)	Mean arter B.P. (mmHg)
	Prost.	Sem. Ves.	Test.	Penis	Urin. Blad.	Kidney		
1	26	15	16	12	13	281	36	100
2	29	23	18	10	14	420	39	100
3	39	29	21	10	16	473	46	90
4	34	28	32	17	6	419	24	85
5	17	29	19	10	20	231	50	85
6	16	14	11	12	8	231	22	110
7	33	9	17	3	6	378	33	75
8	39	31	23	14	30	281	35	105
9	23	28	37	7	6	362	35	65
10	43	23	24	35	9	357	40	112
11	16	38	34	13	31	665	30	114
12	24	16	23	14	4	150	32	95
13	20	21	18	3	3	313	34	75
14	34	28	20	12	23	370	33	75
Mean ± SD	28 ± 9	24 ± 8	22 ± 7	12 ± 8	14 ± 9	352 ± 125	35 ± 7	92 ± 15

They had a diameter of 15 ± 5 μm and were labelled with strontium-85 or cerium-141.

After a period of 60–90 min from induction of analgesia, 250,000 to 400,000 microspheres were suspended in 0.2 ml rat plasma and agitated vigorously for 1 min, after which they were injected through the catheter inserted in the carotid artery. Starting 10 s before and ending 60 s after each injection, a reference blood sample was withdrawn from the left femoral artery at a constant rate of 0.6 ml/min with the suction pump. Microspheres labelled with strontium-85 and cerium-141, respectively were injected alternately.

Immediately before the injection of the microspheres, a blood sample was taken for blood glucose examination to check the condition of the animal. The animals were killed after the injection by cutting through the aorta. The kidney, prostate gland, seminal vesicles, testicles, urinary bladder and penis were sampled. The dissections of the urogenital organs were performed according to previously described techniques [13, 17]. In the dissection of the prostatic gland, efforts were made to free both the ventral and the dorsolateral lobes.

After the samples specimens had been weighed, the organs and the reference blood samples were analysed in a two-channel gamma scintillation detector (Philips-Harshaw, Harshaw Chemic BV, Amsterdam, The Netjherlands) connected to a counter (model 54-22, Selectronic, Copenhagen, Denmark).

The regional blood flows (Q) were determined according to the equation:

$$Q = m \times Qs \times ms^{-1}$$

(m is tissue activity, Qs is blood sampling rate and ms activity of reference blood sample.) Blood flow was expressed as ml x min^{-1} x 100 g tissue wet $weight^{-1}$.

Conventional statistical methods were used. Intra- and inter-group mean values were compared according to Pearson's test for dependent and independent observations. Prior to the experiments, $p < 0.05$ was fixed as significant.

Results

I. In the 14 male rats submitted to blood flow measurements by means of radioactive microsphere technique the following was recorded:

a. Values representing the blood flow in the prostate gland, testicles, seminal vesicles, penis, urinary bladder and kidneys (Table 1).
b. Values of the recorded cardiac output and mean arterial blood pressure (Table 1).
c. Values representing the measured concentrations of glucose in blood which varied between 6.6 and 11.0 mmol/l.

II. a. Significant ($p < 0.05$) correlations were found between the simultaneously recorded blood flow values of the testicles – seminal vesicles (corr. coeff. 0.66), kidneys – seminal vesicles (corr. coeff. 0.59) and kidneys – testicles (corr. coeff. 0.56), respectively. The relationships are graphically illustrated in Fig. 1–3.

b. No significant ($p > 0.05$) correlation was found between the blood flow values of the prostate gland and the simultaneously recorded corresponding values of the testicles, seminal vesicles or kidneys.

c. A significant ($p < 0.05$) agreement of the blood flow between the kidneys was found (corr. coeff. 0.98) (Table 2).

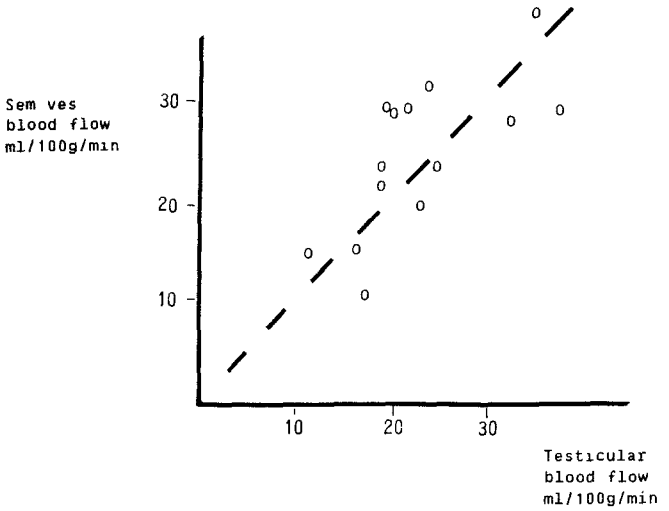

Fig. 1. Plot of values of the blood perfusion of the testicles and the seminal vesicles in 14 rats, illustrating their relationship and signifiant correlation (correlation coefficient 0.66). Each value represents the mean values for the respective paired organ

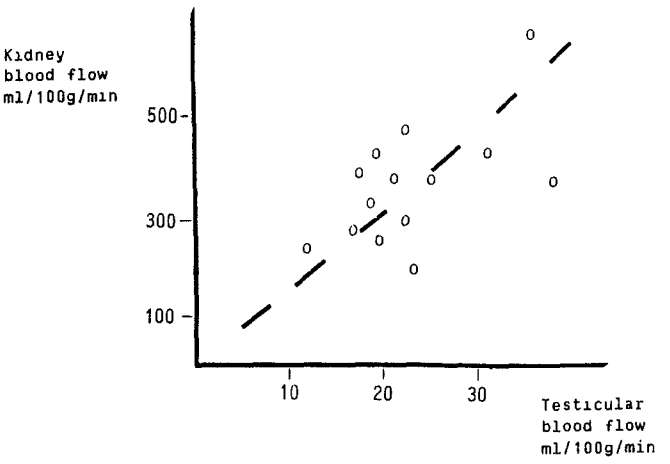

Fig. 3. Plot of values of the blood perfusion of the testicles and kidneys in 14 rats, illustrating their relationship and significant correlation (correlation coefficient 0.56). Each value represents the mean values for the respective paired organ

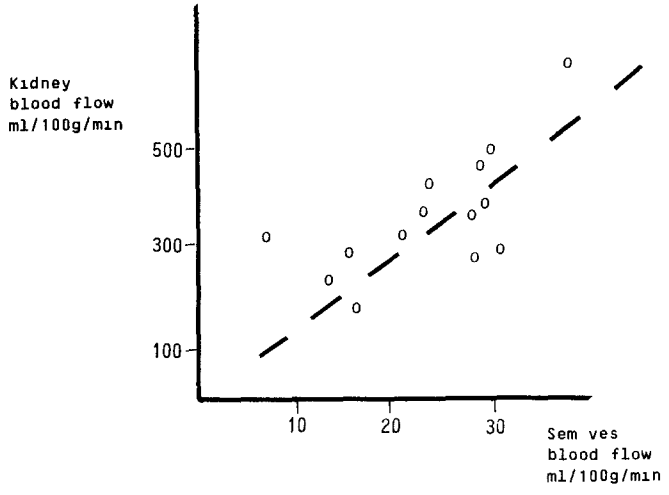

Fig. 2. Plot of values of the blood perfusion of the seminal vesicles and the kidneys in 14 rats, illustrating their relationship and signifficant correlation (correlation coefficient 0.59). Each value represents the mean values for the respective paired organ

Table 2. Blood flow in the paired kidneys of 14 male rats measured by means of radioactive microsphere technique. The blood flow did not differ significantly ($p < 0.05$) between the paired kidneys (corr. coeff. 0.98)

Rat no	Blood flow (ml/100 g/min)	
	right kidney	left kidney
1	279	283
2	410	430
3	479	467
4	424	414
5	216	246
6	234	229
7	390	366
8	290	272
9	392	332
10	343	371
11	645	685
12	139	161
13	317	309
14	375	365

Discussion

The blood flow through an organ is considered to be related to its function [7]. Increased knowledge of genital blood flow would enable better understanding of the physiology and pathophysiology of the male genital organs and would be valuable in evaluating and designing therapeutic procedures.

The male rat has commonly been used in studies of the physiology and pathophysiology of the genital organs. Accordingly, we used male rats.

In the present study the measurements were performed by the radioactive microsphere technique described in 1967 by Rudolph and Heymann [18, 19]. This method, well established for experimental measurements of blood flow in comparable organs of animals, has proved to have good precision and to yield reproducible results [3, 5, 9, 15, 20].

Investigators have previously measured the male genital blood flow in animals by various experimental techniques [2, 4, 5, 7, 8, 21, 22, 24].

Andersson and co-workers [2] used an isotope clearance technique with xenon-133 for measurement of the prostatic blood flow in dogs. The flow varied within the range 31–79 ml/100 g/min. Setchell and Waites [22, 24] used an indicator fraction technique, with iodine-131 and rubidium-86 to measure testicular and prostatic blood flow in sheep and

rat. They found that the average blood flow in the ventral prostatic lobe of rat was 52 ml/100 g/min. The dorsolateral lobe seemed to have a lower perfusion with an average flow of 26 ml/100 g/min. The blood flows in the seminal vesicles and the testicles of rats were 17 and 21 ml/100 g/min, respectively.

Bruce [4] was the first to use the radioactive microsphere technique for genital blood flow measurements. He described the genital blood flow of female rats in relative figures. Damber and Janson [7, 8] used the same method to study the testicular blood flow in rats and measured it to be 20 ml/100 g/min. With this technique, they recorded the blood flow in the ventral prostatic lobe at 22 ml/100 g/min. Damber and Selstam [5, 21] used the microsphere technique to verify that prostatic blood flow was testosterone-dependent.

In the present study, in contrast to previous investigations [2, 4, 5, 7, 8, 21, 22, 24], the blood flow was measured simultaneously in the major genital organs – the prostate gland, seminal vesicles, and testicles. In addition the blood flow was measured in the urinary bladder, penis and the kidneys.

When the organ blood flow is measured with the microsphere technique it is most important that the mixture of the microspheres in the blood stream is homogeneous. The agreement of the recorded blood flow values of the paired kidneys verifies a homogeneous distribution of microspheres in the blood stream and consequently indicates the precision of the obtained blood flow values.

Measurements of blood flow in the penis and urinary bladder in the rat have not been reported previously. The recorded values show the magnitude of the blood flow in these two organs but will not be further discussed in this context.

In view of the anatomy of the rat, the ventral and the dorsolateral lobes of the prostate gland were dissected free as the lobes are considered to have different and distinct characteristics and functions [1, 6, 10, 11, 12, 14, 16, 23].

However, the lobes were scanned together and the recordings thus present the perfusion of the whole prostate gland.

The present results show notable variations of genital organ blood perfusions between individual male rats and they are in agreement with the results of previous investigations [2, 4, 5, 7, 8, 21, 22, 24]. The recorded cardiac output values and blood glucose concentrations are also in agreement with the results of previous investigators [1, 2].

We noticed that the blood perfusion of the testicles and seminal vesicles were related. The blood flow in the prostate gland differed in this context and was not related to the blood flow in any of the other examined genital organs or kidneys. This indicates an interesting feature of the prostate gland. We had suspected a relationship between the prostatic gland and the testicles as the prostatic gland is testosterone-dependent [7].

The microsphere technique is useful for measuring blood perfusion of the male genital organs in rats and we consider it easy to handle. The present results are comparable to the previously published ones [2, 4, 5, 7, 8, 21, 22, 24]. However, the present results represent simultaneously obtained values of the blood flow in several male genital organs.

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L. Gatenbeck, M.D.
Department of Urology
Danderyd Hospital
S-18288 Danderyd
Sweden