

Hematology and Serum Chemistry Reference Values for Pigtailed Macaque (*Macaca nemestrina*) Infants

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The pigtailed macaque infants described in these tables were assessed for various hematology (Table 27-1) and serum chemistry (Table 27-2) measures during their first postnatal year. Nursery infants were raised under standard conditions in the Infant Primate Research Laboratory (IPRL), as described by Ruppenthal and Sackett (1992; see also Chapter 18 in this volume). Mother-raised infants were housed at the Primate Field Station (PFS) of the Washington National Primate Research Center (WaNPRC). Until they were weaned at an average of 6 months, mother-raised animals lived in harem groups of one male and four to eight females or groups containing only four to eight mother-infant pairs. After weaning, infants lived in mixed-sex peer groups containing 8-16 animals.

The data reported here are from samples taken under normal medical conditions, defined as no treatments for medical purposes within 4 weeks

Table 27-1. Hematology Values^a

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Hemoglobin (g/dl)								
Female								
1-3	13.4	13.7	13.1	294	10.9	12.1	9.7	3
4-6	12.1	12.3	11.9	152	11.5	12.1	10.8	10
7-9	11.7	11.9	11.5	138	11.2	11.5	10.8	30
10-12	11.5	11.7	11.2	129	11.4	11.7	11.1	26
Male								
1-3	13.5	13.7	13.3	382	10.6	11.8	9.4	6
4-6	12.1	12.3	12.0	161	12.0	12.6	11.3	7
7-9	11.7	11.9	11.5	133	11.7	12.0	11.4	28
10-12	11.3	11.5	11.1	151	11.4	11.6	11.2	51
Hematocrit (%)								
Female								
1-3	40.0	40.8	39.1	295	37.1	41.6	32.5	3
4-6	38.0	38.6	37.4	153	36.9	39.0	34.8	10
7-9	38.0	38.8	37.3	138	35.5	36.4	34.7	30
10-12	37.4	38.1	36.6	129	36.4	37.1	35.6	26
Male								
1-3	40.2	40.9	39.5	384	36.5	39.4	33.5	6
4-6	37.4	38.0	36.7	161	38.3	40.6	36.0	7
7-9	37.9	38.6	37.3	133	37.3	38.3	36.4	28
10-12	36.7	37.4	36.1	151	37.6	38.1	37.0	51
Total red cells (10⁶/μl)								
Female								
1-3	5.4	5.5	5.4	282	5.7	6.2	5.1	3
4-6	5.9	6.0	5.8	148	5.7	6.0	5.4	10
7-9	5.8	5.9	5.7	136	5.7	5.9	5.5	30
10-12	5.8	5.9	5.6	128	5.8	6.0	5.7	26
Male								
1-3	5.4	5.5	5.3	321	5.7	6.2	5.2	6
4-6	5.9	6.0	5.8	158	6.2	6.7	5.6	7
7-9	5.9	6.0	5.8	130	6.0	6.1	5.8	28
10-12	5.7	5.8	5.6	150	5.8	5.9	5.7	51
Total white cells (10³/μl)								
Female								
1-3	5.4	5.5	5.4	282	5.7	6.2	5.1	3
4-6	5.9	6.0	5.8	148	5.7	6.0	5.4	10
7-9	5.8	5.9	5.7	136	5.7	5.9	5.5	30
10-12	5.8	5.9	5.6	128	5.8	6.0	5.7	26
Male								
1-3	5.4	5.5	5.3	321	5.7	6.2	5.2	6
4-6	5.9	6.0	5.8	158	6.2	6.7	5.6	7
7-9	5.9	6.0	5.8	130	6.0	6.1	5.8	28
10-12	5.7	5.8	5.6	150	5.8	5.9	5.7	51

Table 27-1. *Continued*

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Lymphocytes ($10^3/\mu\text{l}$)								
Female								
1-3	5.4	5.5	5.4	282	5.7	6.2	5.1	3
4-6	5.9	6.0	5.8	148	5.7	6.0	5.4	10
7-9	5.8	5.9	5.7	136	5.7	5.9	5.5	30
10-12	5.8	5.9	5.6	128	5.8	6.0	5.7	26
Male								
1-3	5.4	5.5	5.3	321	5.7	6.2	5.2	6
4-6	5.9	6.0	5.8	158	6.2	6.7	5.6	7
7-9	5.9	6.0	5.8	130	6.0	6.1	5.8	28
10-12	5.7	5.8	5.6	150	5.8	5.9	5.7	51
Neutrophils (%)								
Female								
1-3	49.4	51.4	47.5	290	47.1	57.6	36.6	3
4-6	37.3	39.9	34.8	140	55.3	62.3	48.4	10
7-9	43.8	47.7	39.9	101	55.7	60.1	51.4	25
10-12	50.2	53.8	46.7	107	56.1	60.0	52.1	21
Male								
1-3	50.7	52.5	49.0	379	51.7	59.9	43.5	6
4-6	37.3	39.9	34.7	152	36.9	44.5	29.2	6
7-9	43.8	47.2	40.4	106	44.5	48.1	41.0	25
10-12	48.3	51.8	44.8	126	47.5	51.2	43.9	49
Monocytes (%)								
Female								
1-3	4.4	4.8	4.0	222	5.9	10.5	1.3	3
4-6	3.7	4.3	3.1	100	3.9	5.3	2.5	10
7-9	5.4	6.7	4.1	66	6.5	7.3	5.6	24
10-12	4.1	4.9	3.4	83	5.7	6.6	4.8	20
Male								
1-3	4.3	4.7	4.0	256	4.7	6.5	2.9	6
4-6	4.5	5.5	3.4	99	3.0	4.1	1.8	6
7-9	4.2	4.9	3.5	65	5.5	6.5	4.4	25
10-12	4.9	5.7	4.2	104	4.4	5.1	3.8	48
Eosinophils (%)								
Female								
1-3	1.5	1.7	1.2	133	2.3	4.9	—	3
4-6	1.3	1.5	1.0	76	2.1	3.1	1.1	8
7-9	1.3	1.7	0.9	46	1.8	2.7	1.0	8
10-12	1.1	1.4	0.9	62	1.8	2.5	1.0	11
Male								
1-3	1.4	1.5	1.2	164	1.8	2.2	1.4	6
4-6	1.3	1.6	1.1	86	1.4	1.9	0.9	5
7-9	1.2	1.6	0.8	55	1.2	1.7	0.7	19
10-12	1.0	1.3	0.8	74	1.4	1.8	1.0	40

(Continued)

Table 27-1. *Continued*

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Basophils (%)								
Female								
1-3	0.9	1.0	0.7	120	0.0	—	—	1
4-6	0.8	0.9	0.6	57	0.6	1.0	0.1	6
7-9	0.8	1.0	0.5	43	0.7	1.0	0.4	8
10-12	0.8	1.1	0.5	50	0.7	1.1	0.3	9
Male								
1-3	0.8	1.0	0.7	143	1.5	2.5	0.5	2
4-6	0.6	0.7	0.4	63	1.2	1.4	0.9	3
7-9	0.7	0.9	0.5	50	0.4	0.7	0.2	18
10-12	0.8	1.0	0.7	143	0.5	0.7	0.4	29

^a Values (mean, upper and lower 95% confidence interval bounds, and sample size) by month of age for female and male pigtailed macaques hand reared in the IPRL nursery or mother reared in the PFS. Ages yielding significant ANOVA sex, rearing, or sex × rearing interaction effects are identified by bold italics and specified in Table 27-3.

Table 27-2. Serum Chemistry Values^a

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Sodium (mEq/liter)								
Female								
4-6	144.0	147.7	140.3	43	139.5	144.1	134.9	3
7-9	142.0	145.2	138.8	25	144.1	145.1	143.1	23
10-12	143.7	146.1	141.3	41	144.0	145.8	142.2	19
Male								
4-6	136.6	140.2	133.0	36	144.6	145.8	143.3	3
7-9	142.2	145.0	139.5	25	144.7	147.2	142.3	13
10-12	136.6	140.2	133.0	36	144.9	146.3	143.6	23
Potassium (mEq/liter)								
Female								
4-6	5.9	8.1	3.7	43	4.0	4.9	3.0	3
7-9	5.6	7.5	3.7	25	4.0	4.1	3.8	23
10-12	4.5	6.1	3.0	41	5.4	8.2	2.6	19
Male								
4-6	8.0	12.0	4.0	35	4.0	4.4	3.6	3
7-9	6.2	8.7	3.7	25	4.4	5.0	3.7	13
10-12	8.3	11.3	5.2	57	4.0	4.2	3.9	23
Chloride (mEq/liter)								
Female								
4-6	109.3	112.5	106.2	39	108.1	114.9	101.3	3
7-9	104.5	107.4	101.5	23	106.6	115.6	97.6	23
10-12	107.3	109.5	105.0	17	109.9	112.8	106.9	19

Table 27-2. *Continued*

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Male								
4-6	101.6	104.4	98.7	33	156.1	172.3	154.9	3
7-9	107.6	109.6	105.5	20	110.7	112.8	108.5	13
10-12	106.6	108.8	104.3	28	111.7	113.4	109.9	17
Carbon dioxide (mEq/liter)								
Female								
4-6	16.0	17.7	14.3	30	22.8	27.2	18.5	3
7-9	18.9	21.4	16.3	17	21.9	23.4	20.5	22
10-12	20.0	22.1	18.0	16	24.6	26.7	22.4	19
Male								
4-6	18.2	19.8	16.5	26	22.8	25.6	20.0	3
7-9	19.7	22.2	17.2	11	21.6	23.4	19.8	13
10-12	19.6	21.8	17.5	24	21.9	23.5	20.3	17
Total protein (g/dl)								
Female								
4-6	5.9	6.1	5.7	27	5.6	6.6	4.6	3
7-9	5.9	6.3	5.6	16	6.3	6.5	6.1	23
10-12	5.8	6.2	5.4	15	6.5	6.7	6.3	19
Male								
4-6	6.0	6.2	5.8	18	6.1	6.4	5.9	3
7-9	5.9	6.2	5.6	16	6.2	6.6	5.9	12
10-12	6.2	6.4	6.0	29	6.4	6.7	6.2	18
Albumin (g/dl)								
Female								
4-6	3.9	4.2	3.6	25	2.7	4.3	1.1	3
7-9	3.5	3.9	3.1	16	3.0	3.1	2.8	23
10-12	2.9	3.4	2.4	14	3.0	3.1	2.8	17
Male								
4-6	4.0	4.3	3.7	18	3.5	4.0	2.9	3
7-9	3.4	3.7	3.1	16	3.4	4.2	2.5	12
10-12	3.8	4.2	3.5	23	3.2	3.4	3.1	18
Globulin (g/dl)								
Female								
4-6	1.9	2.4	1.4	9	1.9	—	—	1
7-9	2.7	3.2	2.1	7	3.5	3.8	3.2	8
10-12	2.7	3.2	2.2	7	3.6	4.7	2.4	3
Male								
4-6	1.9	2.2	1.5	13	3.4	4.0	2.7	2
7-9	2.3	2.6	2.0	8	2.7	3.6	1.8	5
10-12	2.1	2.5	1.8	15	2.1	2.1	2.0	2
Calcium (mg/dl)								
Female								
4-6	9.6	9.8	9.3	24	9.0	9.4	8.6	14
7-9	10.2	11.0	9.5	15	9.0	10.4	7.5	3
10-12	9.0	9.4	8.6	14	9.8	9.9	9.6	23

(Continued)

Table 27-2. *Continued*

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Male								
4-6	9.6	9.9	9.3	17	9.9	10.5	9.4	3
7-9	9.7	10.3	9.1	16	9.7	9.9	9.5	11
10-12	9.5	9.7	9.2	23	9.7	9.9	9.6	18
Total bilirubin (mg/dl)								
Female								
4-6	0.3	0.4	0.2	24	0.5	0.7	0.3	3
7-9	0.4	0.5	0.3	15	0.6	0.8	0.4	23
10-12	0.3	0.4	0.2	14	0.5	0.7	0.3	17
Male								
4-6	0.3	0.4	0.2	17	2.2	5.8	—	3
7-9	0.4	0.5	0.3	15	1.2	2.8	—	12
10-12	0.3	0.3	0.2	20	0.4	0.5	0.4	18
Glucose (mg/dl)								
Female								
4-6	101.5	130.9	72.1	40	86.3	146.1	26.6	3
7-9	138.3	211.2	65.4	25	71.5	85.1	58.0	23
10-12	84.1	107.1	61.2	20	63.6	68.7	58.4	19
Male								
4-6	102.6	135.8	69.4	35	66.1	77.9	54.2	3
7-9	74.8	82.8	66.8	21	69.3	81.3	57.3	12
10-12	78.7	93.1	64.3	37	73.4	79.0	67.8	18
Creatinine (µg/liter)								
Female								
4-6	0.7	0.8	0.5	38	0.8	1.1	0.4	3
7-9	0.7	0.9	0.5	24	0.8	0.9	0.6	23
10-12	0.6	0.8	0.5	19	1.0	1.4	0.5	18
Male								
4-6	0.5	0.6	0.5	29	0.7	0.8	0.6	3
7-9	0.7	0.9	0.5	20	1.6	2.5	0.7	12
10-12	0.6	0.8	0.5	30	1.1	1.7	0.5	18
Alkaline (µg/dl)								
Female								
4-6	830.2	922.4	738.0	16	290.8	—	—	1
7-9	661.2	834.8	487.5	11	635.9	731.2	540.5	19
10-12	749.0	907.9	590.2	11	634.4	757.8	511.0	15
Male								
4-6	950.5	1224.6	676.5	11	991.3	1706.9	275.7	3
7-9	832.8	1037.7	627.8	12	696.8	802.4	591.2	12
10-12	561.5	719.8	403.2	13	686.9	795.7	578.1	15
SGOT (µg/liter)								
Female								
4-6	30.9	39.0	22.8	11	76.5	157.8	—	2
7-9	38.8	44.9	32.7	6	51.8	65.5	38.1	23
10-12	44.2	67.0	21.4	7	50.0	64.1	36.0	17

Table 27-2. *Continued*

Age	Nursery				Mother			
	Mean	Up	Low	N	Mean	Up	Low	N
Male								
4-6	37.3	51.9	22.7	9	40.1	43.1	37.0	3
7-9	123.9	227.6	20.2	11	66.6	109.6	23.7	12
10-12	40.2	51.4	29.0	10	47.6	52.6	42.7	18
SGPT ($\mu\text{g}/\text{liter}$)								
Female								
4-6	16.4	22.4	10.3	11	54.4	110.0	—	2
7-9	30.4	40.0	20.9	7	28.8	32.5	25.0	22
10-12	34.6	47.1	22.1	8	29.8	34.3	25.3	17
Male								
4-6	22.9	34.8	11.0	8	28.1	33.0	23.2	3
7-9	47.2	79.0	15.3	12	35.0	42.1	27.9	12
10-12	34.9	55.8	14.0	15	30.6	35.7	25.5	17
GGPT ($\mu\text{g}/\text{liter}$)								
Female								
4-6	113.4	142.0	84.7	10	87.1	200.6	—	2
7-9	100.8	123.8	77.8	6	75.7	88.4	62.9	22
10-12	82.4	120.2	44.7	4	80.2	92.8	67.5	17
Male								
4-6	134.5	162.0	107.0	5	107.8	147.9	67.6	3
7-9	131.4	179.3	83.5	7	73.6	92.0	55.1	12
10-12	85.8	118.9	52.7	7	91.3	105.8	76.8	17

^a Values (mean, upper and lower 95% confidence interval bounds, and sample size) by month of age for female and male pigtailed macaques hand reared in the IPRL nursery or mother reared in the PFS. Ages yielding significant ANOVA sex, rearing, or sex \times rearing interaction effects are identified by bold italics and specified in Table 27-3.

SGOT, serum glutamate oxaloacetate; SGPT, serum glutamate transaminase; GGPT, γ -glutamyl transpeptidase.

before or after the sample. Blood was collected between 7:00 am and 4:00 pm for 95% of the samples studied. Blood was drawn at the time of semiannual TB testing, or from a number of specific studies designed to collect samples for normative values. Most preweaning samples from mother-reared infants were taken without anesthesia, while postweaning samples were taken either with or without ketamine anesthesia. Most IPRL samples were taken without anesthesia. A preliminary analysis, adjusted for age and rearing group as covariates, revealed no anesthesia effects on any of the measures summarized here.

Table 27-3. Analysis of Variance Results for Hematology and Serum Chemistry Measures Analyzed for Sex Effects (Age 1-3 Month Hematology) and Sex (S), Rearing (R), and Sex \times Rearing (S \times R) Effects (Quarters 2, 3, and 4)

	Months 1-3	Months 4-6			Months 7-9			Months 10-12		
	S	S	R	S \times R	S	R	S \times R	S	R	S \times R
Hematology^a										
Hemoglobin										
Hematocrit						**				
Red cells										
MCH			*			*			*	
MCV	*					*			**	*
MCHC			**			*				*
Platelets										
White cells			*							
Lymphocytes		*		*	**	**	*	*		
Neutrophils										
Monocytes										
Eosinophils									**	
Basophils										
Serum chemistry										
Sodium										
Potassium										
Chloride		**	**	**						**
Carbon dioxide			**			*				**
Total protein						*				**
Albumin			**					**	*	
Globulin					*	*		**		
Calcium								*	**	
Bilirubin		**	**	**					**	
Glucose										
Creatinin		*	**	**						
Alkaline										
SGOT		*								
SGPT		*	**							
GGTP						**				

^a MCH, mean corpuscular hemoglobin; MCV, mean cell volume; MCHC, MCH concentration; SGOT, serum glutamate oxaloacetate transaminase; SGPT, serum glutamate pyruvate transaminase; GGTP, γ -glutamyl transpeptidase.

* $P \leq 0.05$.

** $P \leq 0.01$.

Most samples consisted of 1-3 ml of blood drawn into unheparinized syringes from a femoral vein, with blood transferred into EDTA tubes and analyzed immediately or centrifuged and frozen for later analysis. Most (98.6%) of the hematology and serum chemistry assays were

performed in the clinical laboratory at the PFS or the main facility of the WaNPRC or in the Department of Medicine at the University of Washington Medical Center. Assays used standard automated equipment, often supplemented by manual differential counts. A preliminary analysis, adjusted for age and rearing condition as covariates, revealed no significant laboratory differences on any of the measures reported here.

To maintain a reasonable sample size, data describing nursery- and mother-reared female and male infants were summarized in 3-month age intervals (quarterly). The mean value for each subject in each quarter served as the data. There were insufficient serum chemistry samples for any analyses during months 1–3. Univariate analyses of variance were performed for each hematology and serum chemistry measure with sex, rearing group, and the sex \times rearing interaction as factors. Although hematology values for quarter 1 are presented for all groups, they were analyzed only for the nursery-rearing sex effect, as the mother-reared group had too few values for meaningful analysis in quarter 1. Analysis of variance results are presented in Table 27–3.

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