Compilation of empirical ultrasonic properties of mammalian tissues. II

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(Received 1 January 1980; accepted for publication 27 March 1980)

The compilation of the literature on ultrasonic propagation properties of mammalian tissues [J. Acoust. Soc. Am. 64, 423 (1978)] is continued with the addition of 45 papers yielding over 700 lines of parametric data.

PACS numbers: 43.80.Cs, 01.30.Tt

INTRODUCTION

It emerged from the compilation of ultrasonic propagation properties in mammalian tissues [J. Acoust. Soc. Am. 64, 423 (1978); Acoust. Lett. 1, 64 (1978)] that publications containing such measured values were appearing at such a rate in recent years, that an updating could profitably be prepared within one to two years. The present work represents such an undertaking and involves 45 publications; 34 appearing since the termination of searching for the original compilation and 11 that were overlooked in that preparation. This rate activity in the field is believed to warrant serial updating.

I. METHOD

The citations of this work were obtained from searches of the current literature and from inadvertent omissions from the original compilation brought to the attention of the compilers. The earlier adopted procedure of including data from largely peer-reviewed original contributions is continued.

II. ARRANGEMENT OF THE TABLE

As before, each entry number represents a set of data reported in the cited reference, for which the tissue type, species, preparation, anatomical structure and pathology are the same. Each numbered entry line is completed for each column heading. Blank entries imply no change in the data from the above, i.e., ditto marks are employed only in the reference column.

The ordering of entries is as follows:

(1) by tissue type—alphabetically;
(2) by species/age—human first, then all others alphabetically (ordered with increasing age for samples of single species and preparation);
(3) by sample preparation and handling—*in vivo*, then fresh, and finally unspecified;
(4) by an anatomical structure reported within a particular organ or tissue type—alphabetically;
(5) by reported pathologies, normal tissues first, then pathological states—alphabetically.
(6) Any subsequent ordering is in terms of temperature, frequency, or year of measurement.

Acoustic impedance and density information are listed in the remarks column when available. Attenuation values are listed both in Nepers per centimeter and in decibels per centimeter, for which the parenthetic numbers are converted (8.686 dB/Np) from the originally reported values in order to facilitate comparison. The list of abbreviations includes the measurement methods and other often appearing parameters.

III. DISCUSSION

Examination of Table I reveals that investigators generally continue to restrict themselves to much the same tissues and organs which have received abundant attention in the past. Thus the tissues and organs most often measured remain liver, blood, kidney, and muscle. No measurements have yet been reported for often viewed, and clinically important, tissues such as prostate, placenta, thyroid, ovary, adrenal gland, thymus, and lymph node. The general lack of measurements on *in vivo* specimens remains, especially for human tissues. Such paucity of information forces clinicians and medical device manufacturers to employ velocity and attenuation values obtained from animal tissues for estimating parameters, which ultimately will be used for examination of human tissues. The majority of pathologies measured have been restricted to brain tissue. The importance of also reporting the temperature at which measurements are made, and the dependence of the ultrasonic parameters upon temperature, have been given more attention by investigators.

LIST OF TABULATED TISSUE

Tissue	*Entry Number*
Blood	1–10
Blood vessel	11–15
Bone	16–26
Brain	27–33
Breast	34–48
Eye	49–56
Fat	57–66
Heart	67–75

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Kidney	76–82
Limb	83
Liver	84–114
Milk	115–116
Muscle	117–124
Pancreas	125
Skin	126–131
Spleen	132–138
Tendon	139–141
Testis	142–144
Tooth	145–154
Uterus	155

LIST OF ABBREVIATIONS

AI	acoustic interferometry
CARA	critical angle reflection analysis
c	plasma protein concentration (g/100 cm^3)
f	frequency (MHz)
LD	lesion data used to calculate attenuation
NR	not reported
PE	pulse echo
PER	pulse-echo reflection
p.m.	post mortem
PO	pulse overlap
PR	pulse reflection (pulse-echo measurement re-referred to a known medium)
PS	phase speed
PT	pulse transmission
PT(IL)	pulse transmission (insertion loss)
PT-C	pulse transmission (corrected for system losses)
PT-R	pulse transmission (tomographic reconstruction)
RBC	red blood cell
Rm	room temperature
RP	radiation pressure
SA	spectrum analysis
SAR	sing around
S.D.	standard deviation
SLAM	scanning laser acoustic microscopy
T	temperature (°C)
t	time
TAP	total acoustic power
TDS	time delay spectrometry
TOF	time of flight
TOF; PE	time of flight velocity, pulse echo for attenuation
TT	transient thermoelectric
V	volume percent of red blood cells
Z	acoustic impedance $\times 10^5$ (g/cm^2 s)
$\frac{\Delta v}{\Delta T}$	change in velocity with temperature (m/s °C)
ρ	density (g/cm^3)
*	data interpolated from graph

ACKNOWLEDGMENTS

This work was partially supported by an NIH grant from the Institute of General Medical Sciences to the University of Illinois. The authors acknowledge gratefully the efforts to Mrs. Wanda Elliott in the preparation of the manuscript, particularly the table, and of Mr. D. Duback.

TABLE I. ULTRASONIC PROPERTIES OF MAMMALIAN TISSUES

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
	Blood, Blood Vessel											*Blood, Blood Vessel*
BLOOD												
1	Human	fresh heparinized	whole/none		22 ± 1	AI PT-C	3.7 7* 8* 10* 11*	1542 NR	NR (0.17) (0.19) (0.25) (0.26)	 1.5* 1.7* 2.2* 2.3*	± 0.2%; ± 0.1 dB/cm hemoglobin concentration, 8.7 gm/100 cc, deoxygenated	Shung & Reid (1977)
2	Human (male)	fresh	whole/none		37 ± 0.05	AI	7.5	1586.1 ± 5.36 1586.6 ± 5.55 1586.9 ± 5.57 1585.5 ± 5.27 1601.7 ± 7.47	NR		± S.D.; precoagulation onset of coagulation end of coagulation onset of retraction end of retraction	Grybauskas *et al.* (1978)
3	Human (female)	fresh	whole/none		37 ± 0.05	AI	7.5	1579.2 ± 4.55 1579.6 ± 4.5 1580.1 ± 4.53 1579.4 ± 4.72 1596.7 ± 7.34	NR		± S.D.; precoagulation onset of coagulation end of coagulation onset of retraction end of retraction	"
									$\alpha/f^2 \times 10^{17}$ sec^2/cm			
4	Human	fresh	whole/none		37 ± 0.05	AI	7.5	NR	1460-7100		range of absorption values measured during clotting process	"
5	Human	fresh heparinized	whole/sickle cell		22 ± 1	AI PT-C	3.7 4* 6* 7.5* 9* 14* 17*	1551 NR	NR (0.11) (0.20) (0.23) (0.30) (0.48) (0.64)	 1.0* 1.7* 2.0* 2.6* 4.2* 5.6*	± 0.2%; ± 0.1 dB/cm hemoglobin concentration, 8.2 gm/100 cc deoxygenated	Shung & Reid (1977)
6	Human	refrig. (≈14 days) diluted with physiological saline	whole/none		37	PO	1.2	1559.2 1566.8 1578.0 1594.8 1604.3	NR		% plasma protein / % hemoglobin: 0.6 / 1.6; 1.2 / 3.2; 3.1 / 8; 4.6 / 12; 6.2 / 16 ± 0.5%; $v = 3.39c + 1553.42$	Aubert *et al.* (1978)
7	Human	NR	plasma/none		37 ± 0.01	PO	1.2	1529.6 1537.1 1543.1 1548.4	NR		1.29 gm/100 cc plasma protein 2.58 gm/100 cc plasma protein 3.87 gm/100 cc plasma protein 5.16 gm/100 cc plasma protein	"
									$\alpha/f^2 \times 10^{17}$ sec^2/cm			
8	Human	NR	plasma/none		25	PT & AI	1.67 2.81 3.95 6.52 9.10 11.65 14.24 19.39 24.57 25.07 35 65 115	NR	500 370 223 197 162 147 128 112 105 97 80 63 47		PT ± 2%; AI ± 5%	Lang *et al.* (1978)
									$\alpha/f^2 \times 10^{17}$ sec^2/cm			
9	Human	NR	plasma/none		37	PT & AI	3.95 6.50 9.08 11.66 14.23 19.39 24.56 35 65 115	NR	206 168 134 126 115 96 86.3 70 52 42		PT ± 2%; AI ± 5%	"
10	Dog	fresh heparinized	whole/none		37 ± 0.01	PO	1.2	1596.6	NR		measured within 24 hrs after bleeding from 7 dogs; 4.2% plasma protein; 10.8% hemoglobin	Aubert *et al.* (1978)
BLOOD VESSEL												
11	Beef	less than 3 days, stored at 4°C	aortic arch/none		22 ± 1	PR	5	1569 ± 10.8	NR		± S.D.; average of 50 measurements; $\rho = 1.062 \pm 0.0059$, average of 12; $Z = 1.666 \pm 0.015$, data also given for tissue constituents	Shung & Reid (1978)

TABLE I. *(Continued)*

Blood Vessel, Bone, Brain

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP. (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
12	Beef	less than 3 days, stored at 4°C	pulmonary trunk	none	22 ± 1	PR	5	1545 ± 9.6	NR		± S.D., average of 50 measurements; ρ = 1.044 ± 0.0051, average of 12; Z = 1.613 ± 0.013, data also given for tissue constituents	Shung & Reid (1978)
13	Beef	less than 3 days, stored at 4°C	vena cava	none	22 ± 1	PR	5	1552 ± 10.4	NR		± S.D., average of 50 measurements; ρ = 1.054 ± 0.0046, average of 12; Z = 1.636 ± 0.013; data also given for tissue constituents	"
14	NR	formalin fixed	aorta and iliac arteries	none	NR	PR	5	NR	(0-1.73)	0-15	none	Hartley & Strandness (1969)
15	NR	formalin fixed	aorta and iliac arteries	calcified	NR	PR	5	NR	(11.5 - 14.9)	100-130	none	"
BONE												
16	Human 18-40 yrs.	*in vivo*	tiba	none	37	TOF; PE	0.100	3375 ± 188	(0.29 ± 0.03)	2.56 ± 0.26	average 10 measurements	Shalanskii *et al.* (1976)
17	Human	p.m.	femur	none	NR	TOF	0.100	2844.8 ± 153.6	NR		none	"
18	Human	p.m.	tiba	none	NR	TOF; PE	0.100	3238.3 ± 117.9	(0.215 ± 0.04)	1.87 ± 0.34	none	"
19	Human 40 yrs.	p.m. stored -4 to 7°C machined; flat	tiba	none	NR	TOF; PE	0.150	3472 ± 0.47% 3640	0.101 ± 7.3%	(0.88)	none mean velocity over tibial cross section	Vilks *et al.* (1974)
20	Human 40 yrs.	stored -4 to 7°C machined flat	tiba outer layer	none	NR	TOF	0.150	3397 - 3518 3247 - 3708	NR		parallel to axis perpendicular to axis	"
21	Human 40 yrs.	stored -4 to 7°C machined flat	tiba inner layer	none	NR	TOF	0.150	3407 - 3525 3367 - 3506	NR		parallelto axis perpendicular to axis	"
22	Beef (adult)	obtained fresh then ground and embedded	tibia	none	23	TOF	10	3810 - 3920 3180 - 3490 3160 - 3270	NR		ρ = 2.00 2.10 parallel to bone axis ρ = 1.98 - 2.12 perpendicular to bone axis ρ = 1.95 to 2.05 neither parallel nor perpendicular to bone axis	Lees *et al.* (1979)
23	Beef (adult)	dehydrated at room temp. in vacuum for 7 days; ground and embedded	tibia	none	23	TOF	10	4180 - 4310 3460 - 3790 3160 - 3270	NR		parallel to bone axis perpendicular to bone axis neither parallel nor perpendicular to bone axis	"
24	Beef (adult)	rehydrated sample above	tibia	none	23	TOF	10	3750 - 3920 3200 - 3550 3170 - 3220	NR		parallel to bone axis perpendicular to bone axis neither parallel nor perpendicular to bone axis	"
									dB/cm/MHz			
25	Beef	freshly obtained then machined flat	cortical	none	NR	PT & SA	2.5-8 2.5-9	NR	7.6 4.0		shear longitudinal	Garcia *et al.* (1978)
26	Beef	decalcified	cortical	none	NR	PT & SA	1 - 6.5	NR	6 3.45 1.10		longitudinal; Δρ= 0.0% (normal) Δρ = 31% decalcified Δρ = 45% decalcified	"
BRAIN												
27	Rat	*in vivo*	NR	none	37	LD	3.3	NR	0.32	(2.7)	none	Lee *et al.* (1979)
28	Cat	fresh	NR	none	37	TT	0.7 1 7	NR	0.014 ± 0.003 0.029 ± 0.004 0.23 ± 0.09	(0.12 ± 0.03) (0.25 ± 0.03) (1.9 ± 0.78)	absorption; stored at room temperature in physiological saline; measured <1 - 2 hours after excision	Goss *et al.* (1979)
29	Dog	fresh	NR	none	35-44*	TOF	5	1565 - 1570*	NR		measured at 0.25°C intervals; measured 5-30 after termination	Nasoni *et al.* (1979)
30	Dog	fresh	NR	none	35-43	TOF	5	1563.2	NR		$\frac{\Delta v}{\Delta T}$ = 0.67 at 37°C $\frac{\Delta v}{\Delta T}$ = 0.62 at 40°C $\frac{\Delta v}{\Delta T}$ = 0.62 at 43°C	Bowen *et al.* (1979)

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL / PATHOLOGY STRUCTURE	TEMP (°C)	METHOD	FREQ (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
Brain, Breast											*Brain, Breast*
31	Beef	formalin fixed (2 mo; 10%)	NR/none	10*	SA	1	NR	(0.034)	0.30*	± 0.2°C; measured 44, frequency from 1 - 7 MHz	Bamber & Hill (1979)
				18*				(0.080)	0.70*		
				37*				(0.12)	1.1*		
				58*				(0.09)	0.8*		
				10*		2		(0.26)	2.3*		
				18*				(0.21)	1.8*		
				37*				(0.19)	1.7*		
				58*				(0.16)	1.4*		
				10*		3		(0.51)	4.4*		
				18*				(0.44)	3.8*		
				37*				(0.37)	3.2*		
				58*				(0.31)	2.7*		
				10*		4		(0.78)	6.8*		
				18				(0.66)	5.7*		
				37				(0.56)	4.9*		
				58				(0.48)	4.2*		
				10		5		(1.0)	9.0*		
				18				(0.92)	8.0*		
				37				(0.74)	6.4*		
				58				(0.68)	5.9*		
32	NR	unfixed	NR/none	NR	NR	6	1534	(0.611)	5.31	ρ = 1.037; Z = 1.587	Hrazdira (1978)
33	NR	formalin fixed (10%)	NR/none	NR	NR	6	1570	(0.968)	8.41	ρ = 1.078; Z = 1.677	"
BREAST											
34	Human	*in vivo*	NR/none	body	PER	1.76	NR	(0.06 - 0.13)	0.5 - 1.1	none	Chevnenko & Yukhananov (1971)
35	Human	*in vivo*	NR/cancer	body	PER	1.76	NR	(0.17 - 0.30)	1.5 - 2.6	none	"
36	Human	*in vivo*	NR/fibrous mastopathy	body	PER	1.76	NR	(0.29 - 0.44)	2.5 - 3.8	none	"
37	Human	*in vivo*	NR/mastopathy	body	PER	1.76	NR	(0.13 - 0.18)	1.1 - 1.6	none	"
								dB/cm/MHz			
38	Human 54 - 74 yrs.	fresh p.m.	NR/none	37 ± 0.2	SA	0.5-6	NR	0.75 ± 0.3		average 6 samples; $f^{1.5}$ dependence	Foster & Hunt (1979)
								$\alpha/f^2 \times 10^{17}$ sec^2/cm			
39	Human 45-52 yrs.	*in vitro*	premenopausal/ cyst liquid	37	PT & AI	6.50	NR	315		sample #2; PT ± 2%; AI ± 5%	Lang *et. al.* (1978)
						9.08		233			
						14.23		180			
						6.50		255		sample #3	
						9.08		216			
						11.66		186			
						14.23		169			
						19.39		141			
						25.07		126			
						35		102			
						65		73.3			
						85		64			
						115		57.7			
						6.50		130		sample #6	
						9.08		105			
						11.66		88.5			
						14.23		80			
						19.39		65			
						24.56		59			
						6.50		124		sample #7	
						9.08		118			
						11		109			
						15.16		86			
						25.07		65			
						35		56.5			
						45		49			
						65		42.5			
						85		39.5			
						115		35.5			
40	Human 45-52 yrs.	*in vitro*	postmenopausal/ cyst liquid	37	PT & AI	6.50	NR	124		sample #4; PT ± 2%; AI ± 5%	"
						9.08		103			
						11.66		88.8			
						14.23		81			
						19.39		70			
						14.23		81.2		sample #5; hysterectomied	
41	Human 77 yrs.	*in vitro*	postmenopausal/ cyst liquid	37	PT & AI	3.95	NR	302		sample #7; PI ± 2%; AI ± 5%	"
						6.50		258			
						9.08		209			
						11.66		184			
						14.23		167			
						19.39		138			
						24.56		121			
						25.07		110			
						35		91			
						65		68			
						115		55			
				25		1.67		670			
						2.81		470			
						3.95		348			
						6.52		277			
						9.10		232			
						11.65		219			
						14.24		185			
						19.39		166			

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
Breast, Eye												*Breast, Eye*
41	Continued						24.57			148		
							25.07			133		
							35			113		
							65			76		
							115			57		
									$\alpha/f^2 \times 10^{17}$ sec^2/cm			
42	Human 77 yrs.	*in vitro*	postmenopausal/ cyst liquid		25	PT & AI	2.81	NR		152	sample #1 PT ±2%; AI ± 5%; pH = 0.95	Lang *et al.* (1978)
										150	1.53	
										155	2.05	
										165	2.67	
										155	3.33	
										125	4.45	
										122	5.3	
										114	6.0	
										119	6.6	
										122	7.1	
										125	8.3	
										144	9.2	
										170	9.9	
										195	10.3	
										267	10.9	
										317	11.3	
										295	11.65	
										230	11.97	
										145	12.5	
										137	13.15	
43	Human 77 yrs.	*in vitro*	postmenopausal/ cyst liquid		25	PT & AI	2.81	NR		470	sample #1 PT ± 2%; AI ± 5%; concentration dependence C = C_o	"
										355	$0.8C_o$	
										266	$0.6C_o$	
										185	$0.4C_o$	
										122	$0.25C_o$	
										106	$0.22C_o$	
										53	$0.10C_o$	
44	Human	formalin fixed (2 wks; 10%)	areola/none		23	SA	1.6*	NR	(0.23)	2.0*	none	Fry *et al.* (1979)
							3*		(0.37)	3.2*		
							4*		(0.49)	4.3*		
							5*		(0.63)	5.5*		
45	Human	formalin fixed (2 wks; 10%)	nipple/none		23	SA	1.6*	NR	(0.24)	2.1*		
							2.7*		(0.37)	3.2*		
							3.1*		(0.46)	4.0*		
							3.9*		(0.56)	4.9*		
							4.8*		(0.79)	6.9*		
46	Human	formalin fixed (2 wks; 10%)	NR/malignant mass		23	SA	1.5	NR	(0.92)	8	none	"
47	Human	formalin fixed (2 wks; 10%)	NR/malignant tumor		23	SA	2	NR	(2.4)	21	none	"
48	Human	formalin fixed (2 wks; 10%)	NR/neoplastic		23	SA	2	NR	(1.5)	13	none	"
EYE												
									dB/cm/MHz			
49	Human	*in vivo*	choroid/malignant melanoma		37	SA	5-12	NR	0.9		none	Lizzi *et al.* (1978)
50	Human	excised stored at 4°C; 19-36 days	aqueous/none		22 ± 0.1	PT	4.2 wide band	1514.3 ± 3.9 1510.4 ± 8.6	NR		± S.D.; samples from 2 eyes; 20 measurements each	Round & Chivers (1978)
51	Human	excised stored at 4°C; 19-36 days	cornea/none		22 ± 0.1	PT	4.2 wide band	1632.1 ± 3.8 1632.5 ± 6.1	NR		± S.D.; samples from 2 eyes	"
52	Human	excised stored at 4°C; 19-36 days	lens/none		22 ± 0.1	PT	4.2 wide band	1557.6 ± 9.6 1538.1 ± 10.6	NR		± S.D.; samples from 2 eyes	"
53	Human	excised stored at 4°C; 19-36 days	sclera/none		22 ± 0.1	PT	4.2 wide band	1743 ± 27.6 1745 ± 55	NR		± S.D.; samples from 2 eyes; 10 measurements each	"
54	Human	excised stored at 4°C; 19-36 days	vitreous/none		22 ± 0.1	PT	4.2 wide band	1510.7 ± 7.3 1505 ± 2.4	NR		± S.D.; samples from 2 eyes; 20 measurements each	"
55	Beef or pig	NR	choroid/none		20	TOF	6	1533 ± 20	NR		average 10 measurements each of 10 specimens	Oksala & Varonen (1965)
56	Beef or pig	NR	sclera/none		20	TOF	6	1604 ± 6	NR		average 10 measurements each of 10 specimens	"

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np) cm	ATTENUATION (dB) cm	REMARKS	REFERENCE
Fat, Heart												*Fat, Heart*
FAT												
57	Human	*in vitro*	abdominal/none		35	PE	2	1476	NR		maintained near body temperature	Bullen *et al.* (1965)
58	Human	NR	subcutaneous cellular tissue/ none		NR	PT-C	0.88	NR	(0.07)	0.6	none	Chevnenko & Yukhananov (1971)
							2.64		(0.18)	1.6		
						PER	0.88		(0.67)	0.58		
							2.64		(0.20)	1.7		
59	Beef	fresh	peritoneal/none		10	PE	10	1680*		NR	± 1%; ± 0.2°C	Bamber & Hill (1979)
					20			1575*				
					30			1490*				
					44			1390*				
					60			1345*				
60	Beef	fresh	peritoneal/none		10*	SA	1	NR	(0.69)	6.0*	± 10%; ± 0.2°C	"
					20*				(0.46)	4.0*		
					30*				(0.23)	2.0*		
					37*				(0.24)	2.1*		
					60*				(0.34)	3.0*		
					20*		2		(0.76)	6.6*		
					30*				(0.37)	3.2*		
					37*				(0.30)	2.6*		
					60*				(0.46)	4.0*		
					20*		3		(1.1)	9.5*		
					30*				(0.53)	4.6*		
					37*				(0.37)	3.2*		
					60*				(0.76)	6.6*		
					30*		4		(0.83)	7.2*		
					37*				(0.48)	4.2*		
					60*				(0.84)	7.3*		
					30*		5		(1.1)	10.0*		
					37*				(0.69)	6.0*		
					60*				(0.94)	8.2*		
					30*		6		(1.4)	12.5*		
					37*				(0.80)	7.0*		
					60*				(1.0)	9.0*		
					30*		7		(1.8)	16.0*		
					37*				(0.92)	8.0*		
					60*				(1.1)	9.5*		
61	Beef	refrig.	NR/none		Rm	PR	5	1480 ± 3.7		NR	± S.D.; 50 measure-ments	Sollish (1979)
62	Dog	*in vivo*	omentum/none		36.3	TOF	5	1459		NR	none	Nasoni *et al.* (1979)
63	Dog	*in vitro*	omentum/none		36.3	TOF	5	1452		NR	velocity measure-ments in intervals of 0.25°C over range indicated	"
					35-44			1455 - 1432				
64	Dog	fresh	stomach/none		37	TOF	5	1411.9		NR	$\frac{\Delta v}{\Delta T}$ =-2.89 at 37°C	Bowen *et al.* (1979)
											$\frac{\Delta v}{\Delta T}$ =-2.85 at 40°C	
											$\frac{\Delta v}{\Delta T}$ =-2.86 at 43°C	
65	Dog	refrig. (5 hrs.)	stomach/none		37	TOF	5	1412.9		NR	$\frac{\Delta v}{\Delta T}$ =-3.43 at 37°C	"
											$\frac{\Delta v}{\Delta T}$ =-2.86 at 40°C	
											$\frac{\Delta v}{\Delta T}$ =-2.91 at 43°C	
66	Pig	fresh stored at 5°C	backfat/none		4 ± 1	TDS	2*	NR	(1.0)	9.0*	± 1.5 dB/cm; ob-tained day after slaughter	Gammell *et al.* (1979)
							4*		(2.4)	20.8*		
					20 ± 1		2*		(0.80)	7.0*		
							4*		(1.8)	15.3*		
					37 ± 1		2*		(0.34)	3.0*		
							4*		(0.63)	5.5*		
							6*		(0.98)	8.5*		
							8*		(1.4)	12.5*		
							9.9*		(2.0)	17.5*		
					49		2*		(0.23)	2.0*		
							4*		(0.40)	3.5*		
							6*		(0.69)	6.0*		
							8*		(1.0)	9.0*		
							9.9*		(1.6)	13.5*		
HEART												
67	Beef	less than 3 days, stored at 4°C	ventricles & atria/none		22 ± 1	PR	5	1546 ± 4.7		NR	± S.D., average of 50 measurements; ρ = 1.048 ± 0.0036, average of 12 Z = 1.620 ± 0.0074, data also given for tissue constituents	Shung & Reid (1978)
68	Cat	fresh <1-2 hrs. p.m.	NR/none		37	TT	0.7	NR	0.018 ± 0.009	(0.156 ± 0.078)	absorption; ± S.D.	Goss *et al.* (1979)
							1		0.033 ± 0.006	(0.286 ± 0.052)		
							7		0.21 ± 0.03	(1.8 ± 0.3)		
69	Dog	fresh	NR/none		35-43*	TOF	5	1592-1602*		NR	measured at 0.25°C intervals over temperature range indicated	Nasoni *et al.* (1979)

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION (Np/cm)	ATTENUATION (dB/cm)	REMARKS	REFERENCE
Heart, Kidney												*Heart, Kidney*
70	Dog	formalin fixed (1 yr, 10%)	NR/non-infarcted region		NR	SLAM	100	1580 ± 20	41-68	(356-591)	± velocity variation in sample	Yuhas & Kessler (1979)
								NR	37-61	(321-530)	typical values; attenuation ± 10%	
									48	(417)	off axis component perpendicular to grain	
									43	(373)	off axis component parallel to grain	
71	Dog	formalin fixed (1 yr, 10%)	NR/infarct		NR	SLAM	100	NR	38-100	(330-867)	off axis component perpendicular to grain	"
									27-70	(234-608)	off axis component parallel to grain localized variations characteristic of infarction	
									Np/cm/MHz			
72	Dog	NR	left ventricle/ none		NR	PT-R	4-7	NR	0.073 ± 0.92		ρ = 1.06	Klepper *et al.* (1977)
							5		0.27	(2.3)		
									Np/cm/MHz			
73	Rabbit (young)	NR	NR/none		NR	PT	2-10	NR	0.075 ± 0.003		9 areas of myocardium from 3 animals; 57 measurements; collagen concentration ~ 0.77 ± 0.02% wet weight	Mimbs *et al.* (1978)
74	Rabbit (young)	adriamycin given (2.4 mg/kg) for at least 10 weeks	NR/none		NR	PT	2-10	NR	0.115 ± 0.005		6 areas of myocardium from 2 animals; 33 measurements; collagen concentration = 0.95 ± 0.03	"
75	NR	NR	pericardial fluid/none		37 ± 0.01	PO	1.2	1554.2	NR		repeatability ± 0.1%; 0.24% plasma protein	Aubert *et al.* (1978)
KIDNEY												
76	Dog	*in vivo*	NR/none		38.5	TOF	5	1566.6	NR		number of specimens; ±2-2.5 m/s statistical error	Nasoni *et al.* (1979)
								1580.7				
								1569.9				
								1568.6				
					37			1571				
								1567				
								1565				
								1564				
77	Beef 2 yrs. Cat (adult)	fresh measured <1-2 hrs. after excision	NR/none		37	TT	0.7	NR	0.017 ± 0.007	(0.147 ± 0.06)	absorption; stored room temperature in physiological saline until measured	Goss *et al.* (1979)
							1		0.033 ± 0.044	(0.286 ± 0.035)		
							7		0.20 ± 0.002	(1.74 ± 0.017)		
78	Dog	fresh measured 1 hr after sacrifice	NR/none		37	TOF	5	1570.2	NR		3 samples; Δv/ΔT = 1.29-1.35 m/s/°C at 37°C	Bowen *et al.* (1979)
								1566.5			Δv/ΔT = 1.11-1.16 m/s/°C at 40°C	
								1571.1			Δv/ΔT = 0.93-0.98 m/s/°C at 43°C	
79	Dog	fresh 5-30 min after excision	NR/none		35-44*	TOF	5	1576*-1587*	NR		± 2-2.5 ms statistical error; measured in 0.25°C intervals over temperature range	Nasoni *et al.* (1979)
					37			1567				
								1565				
								1564				
								1578				
								1579				
								1583				
								1586				
					38.5			1588.4				
								1579.6				
								1580.2				
								1584.5				
80	Pig	fresh <1 hr. p.m.	NR/none		4 ± 1	TDS	2*		(0.15)	1.3*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell *et al.* (1979)
							4*		(0.37)	3.2*		
							6*		(0.63)	5.5*		
							8*		(0.98)	8.5*		
							9.9*		(1.5)	12.6*		
					20 ± 1		2*		(0.57)	0.5*		
							4*		(0.29)	2.5*		
							6*		(0.46)	4.0*		
							8*		(0.69)	6.0*		
							9.9*		(0.90)	7.8*		
					37 ± 1		2		(0.23)	2.0		
							4		(0.43)	3.7		
							6		(0.57)	5.0		
							8		(0.79)	6.9		
							9.9		(1.0)	9.0		
81	NR	unfixed	NR/none		NR	NR	6	1532	(0.778)	6.76	ρ = 1.032 Z = 1.567	Hrazdira (1978)
82	NR	formalin fixed (10%)	NR/none		NR	NR	6	1547	(1.04)	9.0	ρ = 1.046 Z = 1.615	"

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
Limb, liver												*Limb, liver*
LIMB												
83	Human (male)	*in vivo*	forearm/none		body	PR	5	1583.4 ± 1.0 1579.8 ± 1.7	NR		± S.D.; 50 individual measurements on each target	Sollish (1979)
LIVER												
84	Human	p.m.	NR/none		5* 12* 21* 30* 37* 43* 47*	PE	10	1550* 1562* 1588* 1600* 1608* 1610* 1612*	NR		± 0.2°C; ± 1%	Bamber & Hill (1979)
85	Human	p.m.	NR/none		5* 11* 22* 30* 42* 5* 11* 22* 30* 42* 5* 11* 22* 30* 42* 5* 11* 22* 30* 42* 5* 11* 22* 30* 42*	SA	1 2 3 4 5 6 7 	NR	(0.14) (0.17) (0.18) (0.18) (0.18) (0.24) (0.24) (0.21) (0.21) (0.19) (0.34) (0.31) (0.29) (0.28) (0.25) (0.44) (0.38) (0.32) (0.29) (0.28) (0.49) (0.44) (0.37) (0.34) (0.32) (0.66) (0.54) (0.44) (0.40) (0.37) (0.83) (0.69) (0.56) (0.52) (0.48)	1.2* 1.5* 1.6* 1.6* 1.6* 2.1* 2.1* 1.8* 1.8* 1.7* 3.0* 2.7* 2.5* 2.4* 2.2* 3.8* 3.3* 2.8* 2.5* 2.4* 4.3* 3.8* 3.2* 3.0* 2.8* 5.7* 4.7* 3.8* 3.5* 3.2* 7.2* 6.0* 4.9* 4.5* 4.2*	± 0.2°C; ± 10%	"
86	Human	autopsy (refrig. 60 hrs.)	NR/micronodular cirrhosis		4 ± 1 20 ± 1 37 ± 1 	TDS	2* 4* 6* 8* 9.9* 2* 4* 6* 8* 9.9* 2* 4* 6* 8* 9.9*	NR	(0.48) (0.92) (1.5) (2.1) (2.8) (0.30) (0.69) (1.1) (1.56) (2.06) (0.23) (0.52) (0.92) (1.3) (1.8)	4.2* 8.0* 13.0* 18.6* 24.0* 2.6* 6.0* 9.5* 13.6* 17.9* 2.0* 4.5* 8.0* 11.5* 15.5*	± 1.5 dB/cm	Gammell *et al.* (1979)
									dB/cm/MHz			
87	Human	p.m.	NR/multiple metastæses		37 ± 2	SA	0.5-6	NR	0.7 ± 0.2		none	Foster & Hunt (1979)
88	Human	unfixed	NR/none		NR	NR	1 2 3 6	NR	(0.131) (0.272) (0.382) (0.828)	1.14 2.36 3.32 7.19	none	Hrazdira (1978)
89	Human	fixed	NR/none		NR	NR	1 2 3 6	NR	(0.185) (0.378) (0.580) (1.21)	1.61 3.29 5.04 10.50	none	"
									Np/cm/MHz			
90	Human	fixed	NR/none		NR	PER	4.5-7.8*	NR	0.3*		none	Richter & Millner (1978)
									dB/cm/MHz			
91	Human	NR	NR/none		NR	SA	2.25	NR	1.32 ± 0.3		autopsy specimens; 10 slices from 5 different livers	Kuc *et al.* (1978)
92	Human	NR	NR/none		NR	PT-C PER	0.88 2.64 0.88 2.64	NR	(0.13) (0.39) (0.15) (0.45)	1.2 3.4 1.3 3.9	none	Chevnenko & Yukhananov (1971)
93	Beef Cat Mouse Pig	fresh measured <1-2 hrs.	NR/none		37	TT	0.5 0.7 1 4 7	NR	0.01 ± 0.006 0.02 ± 0.003 0.023 ± 0.004 0.14 ± 0.03 0.24 ± 0.02	(0.09 ± 0.05) (0.17) ± 0.03) (0.20 ± 0.03) (1.2 ± 0.3) (2.1 ± 0.2)	absorption; ± S.D.	Goss *et al.* (1979)

TABLE I. *(Continued)*

Liver NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATHOLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{dB}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE	Liver
94	Beef	fresh measured <30 min	NR/none		8*	PE	10	1610*	NR		± 0.2°C; ± 1%; sample #1	Bamber & Hill (1979)	
					21*			1625*					
					37*			1640*					
					42*			1641*					
					55*			1630*					
					9*			1545*			sample #2		
					20*			1570*					
					30*			1590*					
					43*			1600*					
					65*			1590*					
95	Beef	fresh measured <30 min	NR/none		8*	SA	1	NR	(0.23)	2.0*	± 10%; sample #1	"	
					21*				(0.23)	2.0*			
					37*				(0.24)	2.1*			
					45*				(0.37)	3.2*			
					58*				(0.37)	3.2*			
					8*		2		(0.33)	2.9*			
					21*				(0.28)	2.4*			
					37*				(0.29)	2.5*			
					45*				(0.44)	3.8*			
					58*				(0.44)	3.8*			
					8*		3		(0.54)	4.7*			
					21*				(0.40)	3.5*			
					37*				(0.38)	3.3*			
					45*				(0.52)	4.5*			
					58*				(0.52)	4.5*			
					8*		4		(0.54)	4.7*			
					21*				(0.40)	3.5*			
					37*				(0.37)	3.2*			
					45*				(0.56)	4.9*			
					58*				(0.57)	5.0*			
					8*		5		(0.66)	5.8*			
					21*				(0.48)	4.2*			
					37*				(0.41)	3.6*			
					45*				(0.61)	5.3*			
					58*				(0.68)	5.9*			
					8*		6		(0.79)	6.9*			
					21*				(0.59)	5.1*			
					37*				(0.48)	4.2*			
					45*				(0.69)	6.0*			
					58*				(0.77)	6.7*			
					8*		7		(1.0)	8.7*			
					21*				(0.72)	6.3*			
					37*				(0.61)	5.3*			
					45*				(0.80)	7.0*			
					57*				(0.90)	7.8*			
					9*		1		(0.19)	1.7*	sample #2		
					20*				(0.19)	1.7*			
					30*				(0.19)	1.7*			
					43*				(0.21)	1.8*			
					65*				(0.23)	2.0*			
					9*		2		(0.25)	2.2*			
					20*				(0.23)	2.0*			
					30*				(0.22)	1.9*			
					43*				(0.21)	1.8*			
					65*				(0.26)	2.3*			
					9*		3		(0.33)	2.9*			
					20*				(0.25)	2.2*			
					30*				(0.23)	2.0*			
					43*				(0.23)	2.0*			
					65*				(0.34)	3.0*			
					9*		4		(0.38)	3.3*			
					20*				(0.29)	2.5*			
					30*				(0.31)	2.7*			
					43*				(0.31)	2.7*			
					65*				(0.43)	3.7*			
					9*		5		(0.44)	3.8*			
					20*				(0.34)	3.0*			
					30*				(0.32)	2.8*			
					43*				(0.32)	2.8*			
					65*				(0.49)	4.3*			
					9*		6		(0.54)	4.7*			
					20*				(0.40)	3.5*			
					30*				(0.34)	3.0*			
					43*				(0.36)	3.1*			
					65*				(0.62)	5.4*			
					9*		7		(0.63)	5.5*			
					20*				(0.49)	4.3*			
					30*				(0.46)	4.0*			
					43*				(0.47)	4.1*			
					65*				(0.77)	6.7*			
96	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.04 ± 0.01*	(0.3 ± 0.09)	± S.D.; pressurized 500 lb/in² for 90 min; measured in water	Frizzell *et al* (1979)	
							3.1*		0.21 ± 0.02*	(1.8 ± 0.2)			
							5.3*		0.36 ± 0.01*	(3.1 ± 0.09)			
							7.4*		0.54 ± 0.01*	(4.7 ± 0.09)			
							10.0*		0.75 ± 0.02*	(6.5 ± 0.2)			
97	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.22 ± 0.04*	(1.9 ± 0.3)	± S.D.; measured in saline	"	
							3.1*		0.31 ± 0.01*	(2.7 ± 0.09)			
							5.3*		0.46 ± 0.02*	(4.0 ± 0.2)			
							7.4*		0.72 ± 0.02*	(6.2 ± 0.2)			
							10.0*		0.83 ± 0.02*	(7.2 ± 0.2			

TABLE I. *(Continued)*

Liver

NO	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
98	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.15 ± 0.04*	(1.3 ± 0.3)	± S.D.; measured in water	Frizzell *et al* (1979)
							3.1*		0.21 ± 0.01*	(1.8 ± 0.09)		
							5.3*		0.36 ± 0.01*	(3.1 ± 0.09		
							7.4*		0.54 ± 0.01*	(4.7 ± 0.09)		
							10.0*		0.74 ± 0.02*	(4.3 ± 0.2)		
99	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.45 ± 0.1*	(3.9 ± 0.9)	± S.D.; separated by film from water coupling	"
							3.2*		0.63 ± 0.1*	(5.5 ± 0.9)		
							5.0*		0.77 ± 0.1*	(6.7 ± 0.9)		
							7.4*		1.0 ± 0.1*	(8.7 ± 0.9)		
							10.0*		1.2 ± 0.1*	(10.4 ± 0.9)		
100	Beef	frozen thawed	NR/none		22	TT	1.05*	NR	0.05 ± 0.01*	(0.43 ± 0.09)	± S.D.; absorption; separated by film from water coupling	"
101	Beef	frozen thawed	NR/none		22	TAP	1.0*	NR	0.5 ± 0.33*	(4.3 ± 3)	± S.D.; 3 samples; pressurized 500 lb/in^2 for 90 min after storing at 4° for 15 hrs.; separated by film from water coupling	"
							3.2*		0.23 ± 0.03*	(2.0 ± 0.3)		
							5.0*		0.43 ± 0.03*	(3.7 ± 0.3)		
							7.4*		0.62 ± 0.03*	(5.4 ± 0.3)		
							10.0*		0.84 ± 0.03*	(7.3 ± 0.3)		
102	Beef	frozen thawed	NR/none		22	TAP	0.5*	NR	0.1*	(0.87)	stored in sample holder at 4°C for 15 hrs; separated by film from water coupling	"
							1.0*		0.11*	(0.95)		
							3.2*		0.26*	(2.2)		
							5.0*		0.5*	(4.3)		
							7.4*		0.71*	(6.2)		
							10.0*		1.1*	(9.5)		
103	Beef	formalin fixed (2 mos; 4%)	NR/none		18*	SA	3	NR	(0.28)	2.4*	sample #1; ± 0.2°C; ± 10%	Bamber & Hill (1979)
					28*				(0.23)	2.0*		
					40*				(0.23)	2.0*		
					58*				(0.23)	2.0*		
					18*		4		(0.39)	3.4*		
					28*				(0.33)	2.9*		
					40*				(0.31)	2.7*		
					58*				(0.29)	2.5*		
					18*		5		(0.49)	4.3*		
					28*				(0.41)	3.6*		
					40*				(0.38)	3.3*		
					58*				(0.34)	3.0*		
					18*		6		(0.63)	5.5*		
					28*				(0.53)	4.6*		
					40*				(0.48)	4.2*		
					58*				(0.41)	3.6*		
					18*		7		(0.80)	7.0*		
					28*				(0.68)	5.9*		
					40*				(0.59)	5.1*		
					58*				(0.55)	4.8*		
					18*		3		(0.32)	2.8*	sample #2	
					28*				(0.29)	2.5*		
					40*				(0.26)	2.3*		
					58*				(0.24)	2.1*		
					18*		4		(0.40)	3.5*		
					28*				(0.37)	3.2*		
					40*				(0.32)	2.8*		
					58*				(0.30)	2.6*		
					18*		5		(0.52)	4.5*		
					28*				(0.44)	3.8*		
					40*				(0.38)	3.3*		
					58*				(0.34)	3.0*		
					18*		6		(0.64)	5.6*		
					28*				(0.55)	4.8*		
					40*				(0.46)	4.0*		
					58*				(0.44)	3.8*		
					18*		7		(0.80)	7.0*		
					28*				(0.69)	6.0*		
					40*				(0.57)	5.0*		
					58*				(0.51)	4.4*		
104	Beef	NR	NR/none		16.8	PE	NR	1559-1568	NR		4 samples	Hara *et al.* (1979)
105	Dog	*in vivo*	NR/none		37.75	TOF	5	1601	NR		none	Nasoni *et al.* (1979)
106	Dog	fresh (measured <30 min)	NR/none		38.5	TOF	5	1598.3 1604.3 1603.3	NR		3 samples; ± 2-2.5 m/sec statistical error; $\Delta v/\Delta T$ = 1.06 -1.26	"
					37.75			1597.5 1602.5 1603				
					35-43*			1599-1608*			measured at 0.25°C intervals over temperature range	
									Np/cm/MHz			
107	Dog	fresh	NR/none		NR	SA	3.5-5.5	NR	0.095		none	Kak & Dines (1978)

TABLE I. *(Continued)*

Liver, Milk, Muscle, Pancreas

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
108	Dog	fresh (measured <1 hr.)	NR/none		37	TOF	5	1591.7	NR		3 samples; $\frac{\Delta v}{\Delta T}$ = 0.93-1.13 m/s/°C at 37°C	Bowen *et al.* (1979)
								1594.8			$\frac{\Delta v}{\Delta T}$ = 0.72-0.96 m/s/°C at 40°	
								1604.0			$\frac{\Delta v}{\Delta T}$ = 0.46-0.80 m/s/°C at 43°	
109	Mouse	*in vivo*	NR/none		37	TT	0.5	NR	0.011 ± 0.0025	(0.096 ± 0.022)	absorption; 7 measurements; 2 animals	Frizzell *et al.* (1979)
110	Mouse	fresh	NR/none		37	TT	0.5	NR	0.0093 ± 0.0044	(0.080 ± 0.038)	absorption; 9 measurements; 2 animals	"
111	Mouse	p.m. (24 hrs)	NR/none		37	TT	0.5	NR	0.0090 ± 0.0025	(0.078 ± 0.022)	absorption; 9 measurements; 3 animals	"
112	Pig	fresh	NR/none		4 ± 1	TDS	2*	NR	(0.38)	3.3*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell *et al.* (1979)
							4*		(0.83)	7.2*		
							6*		(1.4)	12.0*		
							8*		(2.0)	17.3*		
							9.9*		(2.7)	23.3*		
					20 ± 1		2*		(0.37)	3.2*		
							4*		(0.75)	6.5*		
							6*		(1.2)	10.3*		
							8*		(1.7)	14.7*		
							9.9*		(2.4)	21.0*		
					37 ± 1		2*		(0.46)	4.0*		
							4*		(0.69)	6.0*		
							6*		(1.0)	9.0*		
							8*		(1.4)	12.0*		
							9.9*		(1.8)	16.0*		
113	NR	unfixed	NR/none		NR	NR	6	1544	(0.828)	7.19	ρ = 1.036; Z = 1.6	Hrazdira (1978)
114	NR	formlin fixed (10%)	NR/none		NR	NR	6	1567	(1.21)	10.5	ρ = 1.054; Z = 1.656	"
MILK												
115	Beef	NR	whole/none		10	SAR	NR	1488*	NR		8% solids not fat; 4% butter fat	Fitzgerald *et al.* (1961)
					20			1509*				
					30			1528*				
					40			1543*				
					50			1553*				
116	Beef	NR	skimmed/none		10	SAR	NR	1483*	NR		8% solids not fat	"
					20			1516*				
					30			1540*				
					40			1554*				
					50			1560*				
MUSCLE												
117	Human	NR	NR/none		NR	PT-C	0.88	NR	(0.15)	1.3	transverse to fibers	Chevnenko & Yukhananov (1971)
							2.64		(0.43)	3.7		
						PER	0.88		(0.15)	1.34		
							2.64		(0.46)	4.0		
									dB/cm/MHz			
118	Beef	fresh	skeletal/none		20 ± 1	PE & SA	1-8	NR	1.1 ± 0.15		5 measurements; perpendicular to fibers	Nassiri *et al.* (1979)
									2.9 ± 0.23		parallel to fibers	
119	Beef	formalin fixed (2 wks; 5%)	skeletal/none		20 ± 1	PE & SA	1-8	NR	1.6 ± 0.15		50 measurements perpendicular to fibers	"
									4.1 ± 0.25		parallel to fibers	
120	Beef	NR	NR/none		17.0	PE	NR	1540-1552	NR		3 samples	Hara *et al.* (1979)
121	Beef	NR	fatty/none		17.2	PE	NR	1522-1550	NR		3 samples	"
122	Dog	*in vivo*	skeletal/none		31.0	TOF	5	1583	NR		none	Nasoni *et al.* (1979)
123	Dog	fresh	skeletal/none		38.5	TOF	5	1608.7	NR		± 2-2.5 m/s statistical error; 2 samples; measured at 0.25°C intervals over entire temperature range	"
					35-41*			1629.3 1606-1612*				
124	Dog	fresh (measured <1 hr.)	skeletal/none		37	TOF	5	1589.1 1603.3 1588.8 1591.6	NR		4 samples $\frac{\Delta v}{\Delta T}$ = 1.08-1.23 at 37°C $\frac{\Delta v}{\Delta T}$ = 0.87-1.03 at 40°C $\frac{\Delta v}{\Delta T}$ = 0.65-0.82 at 43°C	Bowen *et al.* (1979)
PANCREAS												
125	Pig	p.m. 6 hrs	NR/none		37	TDS	2*	NR	(0.02 - 0.3)	0.2 - 3*	range of 4 points; also contains data as shown in Gammell *et al.* (1979) plus data at 5 days p.m. for fixed and unfixed tissue	Le Croisette *et al.* (1979)
							3*		(0.2 - 0.40	2 - 3.5*		
							4*		(0.3 - 0.6)	3 - 5*		

TABLE I. *(Continued)*

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
	Pancreas, Skin, Spleen, Tendon										*Pancreas, Skin, Spleen, Tendon*	
125	Continued						5*		(0.6 - 0.8)	5 - 7*		
							6*		(0.75 - 0.98)	6.5 - 8.5*		
							7*		(0.92 - 1.2)	8 - 10*		
							8*		(1.1 - 1.4)	9.5 - 12*		
							9*		(1.3 - 1.7)	11 - 15*		
SKIN												
126	Human (newborn)	*in vivo*	NR/none		37	PR	2.3	NR		NR	Z = 1.57+0.025* 12 cases	Ogura *et al.* (1978)
127	Human (male)	*in vivo*	upper abdomen/ none		20	PR	2.3	NR		NR	Z = 1.569; 8 cases	"
					25						Z = 1.580	
					30						Z = 1.585	
					35						Z = 1.589	
					37						Z = 1.587	
					40						Z = 1.587	
128	Human (male)	*in vivo*	right subcostal region/none		37	PR	2.3	NR		NR	Z = 1.59 ± 0.15* 17 cases	"
129	Human (female)	*in vivo*	abdominal/none		37	PR	2.3	NR		NR	Z = 1.60 ± 0.04* 22 cases	"
130	Human (female)	*in vivo*	breast/none		37	PR	2.3	NR		NR	Z = 1.57 ± 0.076* 11 cases	"
131	Pig (5 mos.)	*in vivo*	NR/none		NR	PE	15 wide band ± 60	1710		NR	none	Cantrell *et al.* (1978)
									α/ω(dB/cm/MHz)			
						SA	7-13	NR	0.7 ± 0.7		Z = 1.87 ± 0.08	
SPLEEN												
132	Beef	formalin fixed (2 mo;4%)	NR/none		10*	SA	1	NR	(0.14)	1.2*	± 0.2°C; ± 10%	Bamber & Hill (1979)
					18*				(0.16)	1.4*		
					37*				(0.22)	1.9*		
					58*				(0.16)	1.4*		
					10*		2		(0.33)	2.9*		
					18*				(0.29)	2.5*		
					37*				(0.28)	2.4*		
					58*				(0.23)	2.0*		
					10*		3		(0.52)	4.5*		
					18*				(0.46)	4.0*		
					37*				(0.40)	3.5*		
					58*				(0.33)	2.9*		
					10*		4		(0.71)	6.2*		
					18*				(0.67)	5.8*		
					37*				(0.56)	4.9*		
					58*				(0.46)	4.0*		
					10*		5		(0.93)	8.1*		
					18*				(0.89)	7.7*		
					37*				(0.74)	6.4*		
					58*				(0.59)	5.1*		
133	Dog	*in vivo*	NR/none		38.2	TOF	5	1601		NR	none	Nasoni *et al.* (1979)
134	Dog	fresh (<1hr)	NR/none		37	TOF	5	1601.3		NR	$\frac{\Delta v}{\Delta T}$ = 1.31 at 37°C	Bowen *et al.* (1979)
											$\frac{\Delta v}{\Delta T}$ = 1.07 at 40°C	
											$\frac{\Delta v}{\Delta T}$ = 0.84 at 43°C	
135	Dog	fresh (5-30 min)	NR/none		38.2	TOF	5	1567 1635		NR	none	Nasoni *et al.* (1979)
136	Pig	fresh	NR/none		4 ± 1	TDS	2*	NR	(0.23)	2.0*	± 1.5 dB/cm; obtained <1 hr. after slaughter; stored at 5°C until measured	Gammell *et al.* (1979)
							4*		(0.91)	7.9*		
							6*		(1.6)	14.0*		
							8*		(2.5)	21.5*		
							9.9*		(3.7)	31.8*		
					20 ± 1		2*		(0.22)	1.9*		
							4*		(0.63)	5.5*		
							6*		(1.0)	8.9*		
							8*		(1.6)	13.9*		
							9.9*		(2.2)	19.5*		
					37 ± 1		2*		(0.11)	1.0*		
							4*		(0.40)	3.5*		
							6*		(0.69)	6.0*		
							8*		(0.92)	8.0*		
							9.9*		(1.3)	11.6*		
137	NR	unfixed	NR/none		NR	NR	6	1548	(0.508)	4.42	ρ = 1.046; Z = 1.619	Hrazdira (1978)
138	NR	formalin fixed (10%)	NR/none		NR	NR	6	1566	(0.815)	7.08	ρ = 1.061; Z = 1.667	"
TENDON												
139	Beef (≈ 2 yrs.)	fresh (<1-2 hrs. p.m.)	NR/none		37	TT	0.5	NR	0.05 ± 0.03	(0.43 ± 0.3)	± S.D.; absorption stored at room temperature in physiological saline until measured	Goss *et al.* (1979)
							0.7		0.16 ± 0.1	(1.4 ± 0.9)		
							1		0.11 ± 0.04	(0.96 ± 0.3)		
							3		0.53 ± 0.2	(4.6 ± 0.2)		

TABLE I. *(Continued)*

Tendon, Testis, Tooth, Uterus

NO.	SPECIES & AGE	PREP.	ANATOMICAL STRUCTURE	PATH-OLOGY	TEMP (°C)	METHOD	FREQ. (MHz)	VELOCITY (m/sec)	ATTENUATION ($\frac{Np}{cm}$)	ATTENUATION ($\frac{dB}{cm}$)	REMARKS	REFERENCE
139	Continued						4		0.75 ± 0.4	(6.5 ± 3)		
							7		1.4 ± 0.5	(12 ± 4)		
140	Mouse	fresh	tail/none		Rm	SLAM	100	1733 ± 56	NR		± S.D.; bathed in 0.9% saline	Goss & O'Brien (1979)
141	Mouse	rehyd-rated	tail/none		Rm	SLAM	100	1747 ± 66	NR		± S.D.; dried in air 30-127 min then placed on the microscope stage in 0.9% saline and measured	"
TESTIS												
142	Human	*in vivo*	NR/none		30	PE	4	1595	NR		none	Jellins & Barraclough (1978)
143	Mouse	*in vivo*	NR/none		37	TT	1.364	NR	0.023	(0.20)	absorption	Fry *et al.* (1978)
144	Mouse	fresh (<1-2 p.m.)	NR/none		37	TT	0.5	NR	0.0078 ± 0.002	(0.068 ± 0.02)	± S.D.; absorption; stored at room temperature in physiological saline until measured, usually 1-2 hrs. after excision	Goss *et al.* (1979)
							0.7		0.0085 ± 0.001	(0.074 ± 0.009)		
							1		0.015 ± 0.003	(0.13± 0.03)		
							4		0.079 ± 0.02	(0.69 ± 0.2)		
							7		0.12 ± 0.02	(1.0 ± 0.2)		
TOOTH												
145	Human	ground & formalin fixed 5%	incisor dentine/ none		NR	PR	150 NSEC PULSE	3800 ± 370	NR		± S.D.; 8 samples	Barber *et al.* (1969)
146	Human	ground & formalin fixed 5%	incisor enamel/ none		NR	PR	150 NSEC PULSE	6250 ± 410	NR		± S.D.; 8 samples	"
147	Beef	ground & embedded in acrylic plastic	incisor dentine/ none		NR	PR	150 NSEC PULSE	3400	NR		Z = 7.5 ± 2%; ρ = 2.2	Lees (1968)
148	Beef	ground & embedded in acrylic plastic	incisor dentine/ none		NR	CARA	45	4140 ± 0.3%	NR		longitudinal velocity; along long axis	Lees & Rollins (1972)
								2120 ± 0.3%			shear velocity; along long axis	
								1980 ± 0.3%			shear velocity; along long axis	
								3880 ± 0.3%			longitudinal velocity: across long axis	
								2000 ± 0.3%			shear velocity; across long axis	
								1860 ± 0.3%			shear velocity; across long axis	
149	Beef	ground & embedded in acrylic plastic	incisor enamel/ none		NR	PR	150 NSEC PLUSE	6030	NR		Z = 17.8 ± 3.0% ρ = 2.95	Lees (1968)
150	Beef	ground & embedded in acrylic plastic	incisor enamel/ none		NR	CARA	45	6260 ± 0.3%			longitudinal velocity; along long axis	Lees & Rollins (1972)
								3460 ± 0.3%			shear velocity; along long axis	
								3200 ± 0.3%			shear velocity; along long axis	
								5800 ± 0.3%			longitudinal velocity; across long axis	
								3340 ± 0.3%			shear velocity; across long axis	
								3070 ± 0.3%			shear velocity; across long axis	
								5300 ± 0.3%			longitudinal velocity: across long axis	
								3050 ± 0.3%			shear velocity; across long axis	
								2800 ± 0.3%			shear velocity; across long axis	
151	Beef	ground & formalin fixed 5%	incisor dentine/ none		NR	PR	150 NSEC PULSE	3630 ± 300	NR		± S.D.; 4 samples	Barber *et al.* (1969)
152	Beef	ground & formalin fixed 5%	incisor enamel/ none		NR	PR	150 NSEC PULSE	5850 ± 100	NR		2 samples	"
153	Dog	ground & formalin fixed 5%	molar dentine/ none		NR	PR	150 NSEC PULSE	3200 ± 40	NR		2 samples	"
154	Dog	ground & formalin fixed 5%	molar enamel/ none		NR	PR	150 NSEC PULSE	4800	NR		1 sample	"
UTERUS												
155	Human (reproductive age)	*in vivo*	abdomen and uterine wall/none		body	PT	2.25	NR	(0.06 - 0.1)	0.5 - 1	measured attenuation from abdominal surface to inner uterine wall	Bang (1972)

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