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Vivid *i*

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Reference Manual

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Chapter 1
Measurements

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Measurement overview

The following table shows the cardiac measurements available on the Vivid *i* ultrasound unit.

Cardiac measurements

Abbreviation	Definition	Unit
%FS	LV Fractional Shortening, 2D	%
%FS	LV Fractional Shortening, M-mode	%
%IVS Thck	IVS Fractional Shortening, 2D	%
%IVS Thck	IVS Fractional Shortening, M-mode	%
%LVPW Thck	LV Posterior Wall Fractional Shortening, 2D	%
%LVPW Thck	LV Posterior Wall Fractional Shortening, M-mode	%
Ao Arch Diam	Aortic Arch Diameter	cm
Ao asc	Ascending Aortic Diameter	cm
Ao Desc Diam	Descending Aortic Diameter	cm
Ao Isthmus	Aortic Isthmus	cm
Ao Root Diam	Aortic Root Diameter	cm
Ao Root Diam	Aortic Root Diameter, M-mode	cm
AR ERO	PISA: Regurgitant Orifice Area	cm^2
AR Flow	PISA: Regurgitant Flow	ml/s
AR PHT	AV Insuf. Pressure Half Time	ms
AR Rad	PISA: Radius of Aliased Point	cm
AR RV	PISA: Regurgitant Volume Flow	ml
AR Vel	PISA: Aliased Velocity	m/s
AR Vmax	Aortic Insuf. Peak Velocity	m/s
AR VTI	Aortic Insuf. Velocity Time Integral	cm

Abbreviation	Definition	Unit
ARed max PG	Aortic Insuf. End-Diastole Pressure Gradient	mm Hg
ARed Vmax	Aortic Insuf. End-Diastolic Velocity	m/s
AV Acc Slope	Aortic Valve Flow Acceleration	m/s^2
AV Acc Time	Aortic Valve Acceleration Time	ms
AV AccT/ET	AV Acceleration to Ejection Time Ratio	
AV CO	Cardiac Output by Aortic Flow	l/min
AV Cusp	Aortic Valve Cusp Separation, 2D	cm
AV Cusp	Aortic Valve Cusp Separation, M-mode	cm
AV Dec Time	Aortic Valve Deceleration Time	ms
AV Diam	Aortic Diameter, 2D	cm
AV max PG	Aortic Valve Peak Pressure Gradient	mm Hg
AV mean PG	Aortic Valve Mean Pressure Gradient	mm Hg
AV SV	Stroke Volume by Aortic Flow	ml
AV Vmax	Aortic Valve Peak Velocity	m/s
AV Vmean	AV Mean Velocity	m/s
AV VTI	Aortic Valve Velocity Time Integral	cm
AVA (Vmax)	AV Area by Continuity Equation by Peak V	cm^2
AVA (VTI)	AV Area by Continuity Equation VTI	cm^2
AVA Planimetry	Aortic Valve Area	cm^2
AVET	Aortic Valve Ejection Time	ms
AVET	Aortic Valve Ejection Time, M-mode	ms
CO (A-L A2C)	CO 2CH, Single Plane, Area-Length	l/min
CO (A-L A4C)	CO 4CH, Single Plane, Area-Length	l/min
CO (Biplane	CO, Bi-Plane, MOD	l/min
CO (bullet)	CO, Bi-Plane, Bullet	l/min

Abbreviation	Definition	Unit
CO (MOD A2C)	CO 2CH, Single Plane, MOD(Simpson)	l/min
CO (MOD A4C)	CO 4CH, Single Plane, 4CH, MOD(Simpson)	l/min
CO(Cube)	Cardiac Output, 2D, Cubic	l/min
CO(Cube)	Cardiac Output, M-mode, Cubic	l/min
CO(Teich)	Cardiac Output, 2D, Teicholtz	l/min
CO(Teich)	Cardiac Output, M-mode, Teicholtz	l/min
D-E Excursion	MV Anterior Leaflet Excursion	cm
D-E Excursion	Mitral Valve D-E Slope	cm
EDV (bullet)	LV Volume, Diastolic, Bi-Plane, Bullet	ml
EDV(Cube)	Left Ventricle Volume, Diastolic, 2D, Cubic	ml
EDV(Cube)	Left Ventricle Volume, Diastolic, M-mode, Cubic	ml
EDV(Teich)	Left Ventricle Volume, Diastolic, 2D, Teicholz	ml
EDV(Teich)	Left Ventricle Volume, Diastolic, M-mode, Teicholz	ml
EF (A-L A2C)	Ejection Fraction 2CH, Single Plane, Area-Length	%
EF (A-L A4C)	Ejection Fraction 4CH, Single Plane, Area-Length	%
EF (Biplane)	Ejection Fraction, Bi-Plane, MOD	%
EF (bullet)	Ejection Fraction 2CH, Bi-Plane, Bullet	%
EF (MOD A2C)	Ejection Fraction 2CH, Single Plane, MOD(Simpson)	%
EF (MOD A4C)	Ejection Fraction 4CH, Single Plane, 4CH, MOD(Simpson)	%
E-F Slope	Mitral Valve E-F Slope	m/s
EF(Cube)	Ejection Fraction, 2D, Cubic	%

Abbreviation	Definition	Unit
EF(Cube)	Ejection Fraction, M-mode, Cubic	%
EF(Teich)	Ejection Fraction, 2D, Teicholtz	%
EF(Teich)	Ejection Fraction, M-mode, Teicholtz	%
EPSS	E-Point-to-Septum Separation, M-mode	cm
EPSS 2D	E-Point-to-Septum Separation, 2D	cm
ERO	Effective Regurgitant Orifice	cm^2
ESV (bullet)	LV Volume, Systolic, Bi-Plane, Bullet	ml
ESV(Cube)	Left Ventricle Volume, Systolic, 2D, Cubic	ml
ESV(Cube)	Left Ventricle Volume, Systolic, M-mode, Cubic	ml
ESV(Teich)	Left Ventricle Volume, Systolic, 2D, Teicholz	ml
ESV(Teich)	Left Ventricle Volume, Systolic, M-mode, Teicholz	ml
HR	AV Heart Rate, Dop	BPM
HR	Heart Rate, 2D, Teicholtz	bpm
HR	Heart Rate for 2CH study	bpm
HR	Heart Rate for 4CH study	bpm
HR	Heart Rate for 2CH AL study	bpm
HR	Heart Rate for 2CH MOD study	bpm
HR	Heart Rate for 4CH AL study	bpm
HR	Heart Rate for 4CH MOD study	bpm
HR	Heart Rate for Bullet study	bpm
HR	Heart Rate for BiPlane MOD study	bpm
HR	LV Heart Rate, Dop	bpm
HR	Heart Rate, M-mode, Teicholtz	bpm
HR	Heart Rate	bpm
IVC	Inferior Vena Cava	cm

Abbreviation	Definition	Unit
IVCT	Isovolumic Contraction Time	ms
IVRT	Isovolumic Relaxation Time	ms
IVSd	Interventricular Septum Thickness, Diastolic, 2D	cm
IVSd	IVS Thickness, Diastolic, M-mode	cm
IVSs	Interventricular Septum Thickness, Systolic, 2D	cm
IVSs	IVS Thickness, Systolic, M-mode	cm
LA Diam	Left Atrium Diameter, 2D	cm
LA Diam	Left Atrium Diameter, M-mode	cm
LA Diam	Right Atrium Diameter, 2D	cm
LA Major	Left Atrium Major	cm
LA Minor	Left Atrium Minor	cm
LA/Ao	LA Diameter to AoRoot Diameter Ratio, 2D	
LA/Ao	LA Diameter to AoRoot Diameter Ratio, M-mode	
LAEDV (MOD A4C)	LA Volume, Single Plane, MOD	ml
LAESV (MOD A4C)	LA Volume, Systolic, Single Plane, MOD	ml
LIMP	Left Index of Mysocardial Performance	
LVA (s)	Left Ventricular Area, Systolic, 2CH	cm^2
LVAd (A2C)	Left Ventricular Area, Diastolic, 2CH	cm^2
LVAd (A4C)	Left Ventricular Area, Diastolic, 4CH	cm^2
LVAd(sax)	LV area, SAX, Diastolic	cm^2
LVAend (d)	LV Endocardial Area, SAX	cm^2
LVAepi (d)	LV Epicardial Area, SAX	cm^2

Abbreviation	Definition	Unit
LVAs (A4C)	Left Ventricular Area, Systolic, 4CH	cm^2
LVAs(sax)	LV area, SAX, Systolic	cm^2
LVd Mass	LV Mass, Diastolic, 2D	g
LVd Mass	LV Mass, Diastolic, M-mode	g
LVd Mass Index	LV Mass Index, Diastolic, 2D	g/m^2
LVd Mass Index	LV Mass Index, Diastolic, M-mode	g/m^2
LVEDV (A-L A2C)	LV Volume, Diastolic, 2CH, Area-Length	ml
LVEDV (A-L A4C)	LV Volume, Diastolic, 4CH, Area-Length	ml
LVEDV (MOD A2C)	LV Volume, Diastolic, Single Plane, 2CH, MOD	ml
LVEDV (MOD A4C)	LV Volume, Diastolic, Single Plane, 4CH, MOD	ml
LVEDV (MOD BP)	LV Volume, Diastolic, Bi-Plane, MOD	ml
LVESV (A-L A2C)	LV Volume, Systolic, 2CH, Area-Length	ml
LVESV (A-L A4C)	LV Volume, Systolic, 4CH, Area-Length	ml
LVESV (MOD A2C)	LV Volume, Systolic, Single Plane, 2CH, MOD	ml
LVESV (MOD A4C)	LV Volume, Systolic, Single Plane, 4CH, MOD	ml
LVESV (MOD BP)	LV Volume, Systolic, Bi-Plane, MOD	ml
LVESV (MOD LAX)	LV Volume, Diastolic, Apical View, LAX, MOD	ml
LVESV (MOD LAX)	LV Volume, Systolic, Apical View, LAX, MOD	ml
LVET	Left Ventricle Ejection Time	ms
LVIDd	LV Internal Dimension, Diastolic, 2D	cm
LVIDd	LV Internal Dimension, Diastolic, M-mode	cm
LVIDs	LV Internal Dimension, Systolic, 2D	cm

Abbreviation	Definition	Unit
LVIDs	LV Internal Dimension, Systolic, M-mode	cm
LVLd (apical)	Left Ventricular Length, Diastolic, 2D	cm
LVLs (apical)	Left Ventricular Length, Systolic, 2D	cm
LVOT Area	Left Ventricle Outflow Tract Area	cm^2
LVOT CO	Cardiac Output by Aortic Flow	l/min
LVOT Diam	Left Ventricular Outflow Tract Diameter	cm
LVOT max PG	LVOT Peak Pressure Gradient	mm Hg
LVOT mean PG	LVOT Mean Pressure Gradient	mm Hg
LVOT SI	Stroke Volume Index by Aortic Flow	ml/m^2
LVOT SV	Stroke Volume by Aortic Flow	ml
LVOT Vmax	LVOT Peak Velocity	m/s
LVOT Vmean	LVOT Mean Velocity	m/s
LVOT VTI	LVOT Velocity Time Integral	cm
LVPWd	Left Ventricular Posterior Wall Thickness, Diastolic, 2D	cm
LVPWd	Left Ventricular Posterior Wall Thickness, Diastolic, M-mode	cm
LVPWs	Left Ventricular Posterior Wall Thickness, Systolic, 2D	cm
LVPWs	Left Ventricular Posterior Wall Thickness, Systolic, M-mode	cm
LVs Mass	LV Mass, Systolic, 2D	g
LVs Mass	LV Mass, Systolic, M-mode	g
LVs Mass Index	LV Mass Index, Systolic, 2D	g/m^2
LVs Mass Index	LV Mass Index, Systolic, M-mode	g/m^2
LAAd (A2C)	Left Atrium Area, Apical 2C	cm^2
LAAd (A4C)	Left Atrium Area, Apical 4C	cm^2

Abbreviation	Definition	Unit
MCO	Mitral Valve closure to Opening	ms
MP Area	Mitral Valve Prosthesis	cm^2
MR Acc Time	MV Regurg. Flow Acceleration	s
MR ERO	PISA: Regurgitant Orifice Area	cm^2
MR Flow	PISA: Regurgitant Flow	ml/s
MR max PG	Mitral Regurg. Peak Pressure Gradient	mm Hg
MR Rad	PISA: Radius of Aliased Point	cm
MR RV	PISA: Regurgitant Volume Flow	ml
MR Vel	PISA: Aliased Velocity	m/s
MR Vmax	Mitral Regurg. Peak Velocity	m/s
MR Vmax	PISA: CW Peak Velocity	m/s
MR Vmean	Mitral Regurg. Mean Velocity	m/s
MR VTI	Mitral Regurg. Velocity Time Integral	cm
MR VTI	PISA: CW Velocity Time Integral	cm
MV A Dur	Mitral Valve A-Wave Duration	ms
MV A Velocity	MV Velocity Peak A	m/s
MV Acc Slope	Mitral Valve Flow Acceleration	m/s^2
MV Acc Time	Mitral Valve Acceleration Time	ms
MV Acc/Dec Time	MV: Acc.Time/Decel.Time Ratio	
MV an diam	Mitral Valve Annulus Diameter, 2D	cm
MV CO	Cardiac Output by Mitral Flow	l/min
MV Dec Slope	Mitral Valve Flow Deceleration	m/s^2
MV Dec Time	Mitral Valve Deceleration Time	ms
MV E Velocity	MV Velocity Peak E	m/s
MV E/A Ratio	Mitral Valve E-Peak to A-Peak Ratio	
MV max PG	Mitral Valve Peak Pressure Gradient	mm Hg

Abbreviation	Definition	Unit
MV mean PG	Mitral Valve Mean Pressure Gradient	mm Hg
MV PHT	Mitral Valve Pressure Half Time	ms
MV SI	Stroke Volume Index by Mitral Flow	ml/m^2
MV SV	Stroke Volume by Mitral Flow	ml
MV Time to Peak	Mitral Valve Time to Peak	ms
MV Vmax	Mitral Valve Peak Velocity	m/s
MV Vmean	MV Mean Velocity	m/s
MV VTI	Mitral Valve Velocity Time Integral	cm
MVA	Mitral Valve Area	cm^2
MVA By PHT	Mitral Valve Area according to PHT	cm^2
MVA by plan	Mitral Valve Area, 2D	cm^2
MVET	Mitral Valve Ejection Time	ms
P Vein A	Pulmonary Vein Velocity Peak A (reverse)	m/s
P Vein A Dur	Pulmonary Vein A-Wave Duration	ms
P Vein D	Pulmonary Vein End-Diastolic Peak Velocity	m/s
P Vein S	Pulmonary Vein Systolic Peak Velocity	m/s
PAEDP	Pulmonary Artery Diastolic Pressure	mm Hg
PE(d)	Pericard Effusion, M-mode	cm
PEs	Pericard Effusion, 2D	cm
PR max PG	Pulmonic Insuf. Peak Pressure Gradient	mm Hg
PR mean PG	Pulmonic Insuf. Mean Pressure Gradient	mm Hg
PR PHT	Pulmonic Insuf. Pressure Half Time	ms
PR Vmax	Pulmonic Insuf. Peak Velocity	m/s
PR VTI	Pulmonic Insuf. Velocity Time Integral	cm

Abbreviation	Definition	Unit
PRend max PG	Pulmonic Insuf. End-Diastole Pressure Gradient	mm Hg
PRend Vmax	Pulmonic Insuf. End-Diastolic Velocity	m/s
Pulmonic Diam	Pulmonary Artery Diameter, 2D	cm
PV Acc Slope	Pulmonic Valve Flow Acceleration	m/s^2
PV Acc Time	Pulmonic Valve Acceleration Time	ms
PV Acc Time/ET Ratio	PV Acceleration to Ejection Time Ratio	
PV an diam	Pulmonic Valve Annulus Diameter, 2D	cm
PV Ann Area	Pulmonic Valve Area	cm^2
PV CO	Cardiac Output by Pulmonic Flow	l/min
PV CO	Cardiac Output by Pulmonic Flow	l/min
PV max PG	Pulmonic Valve Peak Pressure Gradient	mm Hg
PV mean PG	Pulmonic Valve Mean Pressure Gradient	mm Hg
PV SV	Stroke Volume by Pulmonic Flow	ml
PV Vmax	Pulmonary Artery Peak Velocity	m/s
PV Vmax	Pulmonic Valve Peak Velocity	m/s
PV Vmean	PV Mean Velocity	m/s
PV VTI	Pulmonic Valve Velocity Time Integral	cm
PVA (VTI)	Pulmonary Artery Velocity Time Integral	cm^2
PVein S/D Ratio	Pulmonary Vein SD Ratio	
PVET	Pulmonic Valve Ejection Time	ms
PVPEP	Pulmonic Valve Pre-Ejection Period	ms
PVPEP/ET Ratio	PV Pre-Ejection to Ejection Time Ratio	
Qp/Qs	Pulmonic-to-Systemic Flow Ratio	
RA Major	Right Atrium Major, 2D	cm
RA Minor	Right Atrium Minor, 2D	cm

Abbreviation	Definition	Unit
RAEDV A2C	Right Atrium End Diastolic Volume, Apical 2 chamber	cm^3
RAEDV A-L	RA End Diastolic Volume (A-L)	ml
RAEDV MOD	RA Volume Diastolic, Single Plan, MOD	ml
RAEDV MOD	RA End Diastolic Volume (MOD)	ml
RAESV A-L	RA End Systole Volume (A-L)	ml
RAESV MOD	RA Volume, Systolic, Single Plane, MOD	ml
RAESV MOD	RA End Systole Volume (MOD)	ml
RALd	Right Atrium Length, Diastole	cm
RALs	RA Length, systole	cm
RIMP	Right Index of Myocardial Performance	
RJA (A4C)	Regurgitant jet area	cm^2
RJA/LAA	Regurgitant jet area ratio RJA/LAA	
RV Major	Right Ventricle Major	cm
RV Minor	Right Ventricle Minor	cm
RVAWd	Right Ventricle Wall Thickness, Diastolic, 2D	cm
RVAWs	Right Ventricle Wall Thickness, Systolic, 2D	cm
RVET	Right Ventricle Ejection Time	s
RVIDd	Right Ventricle Diameter, Diastolic, 2D	cm
RVIDd	Right Ventricle Diameter, Diastolic, M-mode	cm
RVIDs	Right Ventricle Diameter, Systolic, 2D	cm
RVIDs	Right Ventricle Diameter, Systolic, M-mode	cm
RVOT Area	Right Ventricle Outflow Tract Area	cm^2
RVOT Diam	RV Output Tract Diameter, 2D	cm

Abbreviation	Definition	Unit
RVOT Diam	RV Output Tract Diameter, M-Mode	cm
RVOT max PG	RVOT Peak Pressure Gradient	mm Hg
RVOT meanPG	RVOT Mean Pressure Gradient	mm Hg
RVOT SI	LV Stroke Volume Index by Pulmonic Flow	ml/m^2
RVOT SV	Stroke Volume by Pulmonic Flow	ml
RVOT Vmax	RVOT Peak Velocity	m/s
RVOT Vmean	RVOT Mean Velocity	m/s
RVOT VTI	RVOT Velocity Time Integral	cm
RVSP	Right Ventricle Systolic Pressure	mm Hg
RVWd	Right Ventricle Wall Thickness, Diastolic, M-mode	cm
RVWs	Right Ventricle Wall Thickness, Systolic, M-mode	cm
RAA (d)	Right Atrium Area, 2D, Diastole	cm^2
RAA (s)	Right Atrium Area, 2D, Systole	cm^2
SI (A-L A2C)	LV Stroke Index, Single Plane, 2CH, Area-Length	ml/m^2
SI (A-L A4C)	LV Stroke Index, Single Plane, 4CH, Area-Length	ml/m^2
SI (Biplane)	LV Stroke Index, Bi-Plane, MOD	ml/m^2
SI (bullet)	LV Stroke Index, Bi-Plane, Bullet	ml/m^2
SI (MOD A2C	LV Stroke Index, Single Plane, 2CH, MOD	ml/m^2
SI (MOD A4C	LV Stroke Index, Single Plane, 4CH, MOD	ml/m^2
SI (Teich)	LV Stroke Index, Teicholz, 2D	ml/m^2
SI (Teich)	LV Stroke Index, Teicholz, M-mode	ml/m^2

Abbreviation	Definition	Unit
SV (A-L A2C)	LV Stroke Volume, Single Plane, 2CH, Area-Length	ml
SV (A-L A4C)	LV Stroke Volume, Single Plane, 4CH, Area-Length	ml
SV (Biplane)	LV Stroke Volume, Bi-Plane, MOD	ml
SV (bullet)	LV Stroke Volume, Bi-Plane, Bullet	ml
SV (MOD A2C)	LV Stroke Volume, Single Plane, 2CH, MOD(Simpson)	ml
SV (MOD A4C)	LV Stroke Volume, Single Plane, 4CH, MOD(Simpson)	ml
SV(Cube)	LV Stroke Volume, 2D, Cubic	ml
SV(Cube)	LV Stroke Volume, M-mode, Cubic	ml
SV(Teich)	LV Stroke Volume, 2D, Teicholtz	ml
SV(Teich)	LV Stroke Volume, M-mode, Teicholtz	ml
Systemic Diam	Systemic Vein Diameter, 2D	cm
Systemic Vmax	Systemic Vein Peak Velocity	m/s
Systemic VTI	Systemic Vein Velocity Time Integral	cm
TCO	Tricuspid Valve Closure to Opening	ms
TR max PG	Tricuspid Regurg. Peak Pressure Gradient	mm Hg
TR mean PG	Tricuspid Regurg. Mean Pressure Gradient	mm Hg
TR Vmax	Tricuspid Regurg. Peak Velocity	m/s
TR Vmean	Tricuspid Regurg. Mean Velocity	m/s
TR VTI	Tricuspid Regurgitation Velocity Time Integral	cm
TV A dur	Tricuspid Valve A-Wave Duration	ms
TV A Velocity	Tricuspid Valve A Velocity	m/s
TV Acc Time	Tricuspid Valve Time to Peak	ms

Abbreviation	Definition	Unit
TV Ann Area	Tricuspid Valve Area	cm^2
TV ann diam	Tricuspid Valve Annulus Diameter, 2D	cm
TV Area	Tricuspid Valve Area, 2D	cm^2
TV CO	Cardiac Output by Tricuspid Flow	l/min
TV Dec Slope	Tricuspid Valve Flow Deceleration	m/s^2
TV E Velocity	Tricuspid Valve E Velocity	m/s
TV E/A Ratio	Tricuspid Valve E-Peak to A-Peak Ratio	
TV max PG	Tricuspid Valve Peak Pressure Gradient	mm Hg
TV mean PG	Tricuspid Valve Mean Pressure Gradient	mm Hg
TV mean PG	Tricuspid Valve Mean Pressure Gradient	mm Hg
TV PHT	Tricuspid Valve Pressure Half Time	ms
TV SV	Stroke Volume by Tricuspid Flow	ml
TV Vmean	TV Mean Velocity	m/s
TV VTI	Tricuspid Valve Velocity Time Integral	cm
VSD max PG	VSD Peak Pressure Gradient	mm Hg
VSD Vmax	VSD Peak Velocity	m/s

Measurement formulas

Formulas–Cardiac

The following table lists the cardiac calculations. The folders where to find the calculations and related measurements are indicated in brakets "[ ]".

%FS [Dimension, Cube/Teicholz] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: (({LVIDd}-{LVIDs})/{LVIDd}) Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz] Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]
%FS [Generic, Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: (({LVIDd}-{LVIDs})/{LVIDd}) Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension] Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]
%IVS Thck [Dimension] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: (({IVSs}-{IVSd})/{IVSd}) Needs measurement: IVSs [Dimension], IVSd [Dimension] Measured by: LVs [2DLV], IVSs [2DCALIPER]
%IVS Thck [Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: (({IVSs}-{IVSd})/{IVSd}) Needs measurement: IVSs [Dimension], IVSd [Dimension] Measured by: IVSs [MMDISCALIPER]
%LVPW Thck [Dimension] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: (({LVPWs}-{LVPWd})/{LVPWd}) Needs measurement: LVPWs [Dimension], LVPWd [Dimension] Measured by: LVs [2DLV], LVPWs [2DCALIPER]
%LVPW Thck [Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: (({LVPWs}-{LVPWd})/{LVPWd}) Needs measurement: LVPWs [Dimension], LVPWd [Dimension] Measured by: LVPWs [MMDISCALIPER]

Ao st junct/Ao [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: {Ao st junct}/{Ao Diam}
Needs measurement: Ao st junct [Dimension], Ao Diam [Dimension]
Measured by: Ao st junct [2DCALIPER]

Ao/LA [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: {Ao Diam}/{LA Diam}
Needs measurement: Ao Diam [Generic, Dimension], LA Diam [Generic, Dimension]
Measured by: LA/Ao [MMLAAO]

AP Area [Aortic]

Mode: CW:PW:VRCW:VRPW
Formula: {LVOT Diam}^2*0.785*({LVOT VTI}/{AP VTI})
Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic], AP VTI [Aortic]
Measured by: AP Area [SDMANTRACE]

AR ERO [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {AR Flow}/{AR Vmax}
Needs measurement: AR Flow [PISA], AR Vmax [PISA]
Measured by: AR Trace [AUTOCALC]

AR RV [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {AR Flow}/{AR Vmax}*{AR VTI}
Needs measurement: AR Flow [PISA], AR Vmax [PISA], AR VTI [PISA]
Measured by: AR Trace [AUTOCALC]

AV Acc Time/ET Ratio [Aortic]

Mode: CW:PW:VRCW:VRPW
Formula: {AV AccT}/{AVET}
Needs measurement: AV AccT [Aortic], AVET [Aortic]
Measured by: AVET [SDTIMECALIPER]

AV Area [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: 3.14/4*{AV Diam}^2
Needs measurement: AV Diam [Dimension]
Measured by: AV Diam [2DCALIPER]

AV CI [Aortic]

Mode: CW:PW:VRCW:VRPW
Formula: (({AV Diam}^2*0.785*{AV VTI})*{HR}/60)/{BSA}
Needs measurement: AV Diam [Aortic], AV VTI [Aortic], HR [Aortic]
Measured by: AV Trace [SDMANTRACE]

AV CO [Aortic] Mode: CW:PW:VRCW:VRPW Formula: ({AV Diam}^2*0.785*{AV VTI})*{HR}/60 Needs measurement: AV Diam [Aortic], AV VTI [Aortic], HR [Aortic] Measured by: AV Trace [SDMANTRACE]
AV SI [Aortic] Mode: CW:PW:VRCW:VRPW Formula: ({AV Diam}^2*0.785*{AV VTI})/{BSA} Needs measurement: AV Diam [Aortic], AV VTI [Aortic] Measured by: AV Trace [SDMANTRACE]
AV SV [Aortic] Mode: CW:PW:VRCW:VRPW Formula: {AV Diam}^2*0.785*{AV VTI} Needs measurement: AV Diam [Aortic], AV VTI [Aortic] Measured by: AV Trace [SDMANTRACE]
AVA (VTI) [Aortic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{LVOT Diam}^2*{LVOT VTI}/{AV VTI} Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic], AV VTI [Aortic] Measured by: AV Trace [AUTOCALC]
AVA Vmax [Aortic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{LVOT Diam}^2*abs({LVOT Vmax}/{AV Vmax}) Needs measurement: LVOT Diam [Aortic], LVOT Vmax [Aortic], AV Vmax [Aortic] Measured by: AV Vmax [AUTOCALC]
AVA Vmax [Aortic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{LVOT Diam}^2*abs({LVOT Vmax}/{AV Vmax}) Needs measurement: LVOT Diam [Aortic], LVOT Vmax [Aortic], AV Vmax [Aortic] Measured by: AV Trace [AUTOCALC]
AVA Vmax, Pt [Aortic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{LVOT Diam}^2*abs({LVOT Vmax}/{AV Vmax}) Needs measurement: LVOT Diam [Aortic], LVOT Vmax [Aortic], AV Vmax [Aortic] Measured by: AV Vmax [AUTOCALC]
AVA Vmax, Pt [Aortic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{LVOT Diam}^2*abs({LVOT Vmax}/{AV Vmax}) Needs measurement: LVOT Diam [Aortic], LVOT Vmax [Aortic], AV Vmax [Aortic] Measured by: AV Trace [AUTOCALC]

CI A-L A2C [Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (({LVEDV A-L A2C}-{LVESV A-L A2C})*{HR}/60)/{BSA}

Needs measurement: LVEDV A-L A2C [Single Plane A2C, AutoBiplane], LVESV A-L A2C [Single Plane A2C, AutoBiplane], HR [Single Plane A2C, AutoBiplane]

Measured by: R-R [2DCALIPER], A2C [2DAUTOVOLUME]

CI A-L A2C [Single Plane A2C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (({LVEDV A-L A2C}-{LVESV A-L A2C})*{HR}/60/Auto)/{BSA}

Needs measurement: LVEDV A-L A2C [Single Plane A2C], LVESV A-L A2C [Single Plane A2C], HR [Single Plane A2C]

Measured by: LVESV A2C [2DVOLUMETRACE]

CI A-L A4C [Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (({LVEDV A-L A4C}-{LVESV A-L A4C})*{HR}/60)/{BSA}

Needs measurement: LVEDV A-L A4C [Single Plane A4C, AutoBiplane], LVESV A-L A4C [Single Plane A4C, AutoBiplane], HR [Single Plane A4C, AutoBiplane]

Measured by: R-R [2DCALIPER], A4C [2DAUTOVOLUME]

CI A-L A4C [Single Plane A4C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (({LVEDV A-L A4C}-{LVESV A-L A4C})*{HR}/60)/{BSA}

Needs measurement: LVEDV A-L A4C [Single Plane A4C], LVESV A-L A4C [Single Plane A4C], HR [Single Plane A4C]

Measured by: LVESV A4C [2DVOLUMETRACE]

CI A-L LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (({LVEDV A-L LAX}-{LVESV A-L LAX})*{HR}/60)/{BSA}

Needs measurement: LVEDV A-L LAX [Single Plane LAX, AutoBiplane], LVESV A-L LAX [Single Plane LAX, AutoBiplane], HR [Single Plane LAX, AutoBiplane]

Measured by: R-R [2DCALIPER], AutoVolume [2DAUTOVOLUME]

CI Biplane [Biplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: d = biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks})

Needs measurement: LVLd A4C [Biplane], LVLd A2C [Biplane], LVLs A4C [Biplane], LVLs A2C [Biplane], HR [Biplane]

Measured by: R-R [2DCALIPER]

CI bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ((d-s)*{ECG/HeartRate}/60)/{BSA} where: s = (8/(3*3.14159))*{LVAs(A4C)}*{LVAs(sax MV)}/{2D/LVIDs} d = (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse], LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse], HR [Biplane Ellipse]

Measured by: R-R [2DCALIPER]

CI bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ((d-s)*{ECG/HeartRate}/60)/{BSA} where: s =5/6*{LVAs(sax)}*{LVLs(apical)} d = 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet], LVAs sax) [Bullet], LVLs apical [Bullet], HR [Bullet]

Measured by: R-R [2DCALIPER]

CI MOD A2C [Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (({LVEDV MOD A2C}-{LVESV MOD A2C})*{HR}/60)/{BSA}

Needs measurement: LVEDV MOD A2C [Single Plane A2C, AutoBiplane], LVESV MOD A2C [Single Plane A2C, AutoBiplane], HR [Single Plane A2C, AutoBiplane]

Measured by: R-R [2DCALIPER], A2C [2DAUTOVOLUME]

CI MOD A2C [Single Plane A2C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (({LVEDV MOD A2C}-{LVESV MOD A2C})*{HR}/60)/{BSA}

Needs measurement: LVEDV MOD A2C [Single Plane A2C], LVESV MOD A2C [Single Plane A2C], HR [Single Plane A2C]

Measured by: LVESV A2C [2DVOLUMETRACE]

CI MOD A4C [Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (({LVEDV MOD A4C}-{LVESV MOD A4C})*{HR}/60)/{BSA}

Needs measurement: LVEDV MOD A4C [Single Plane A4C, AutoBiplane], LVESV MOD A4C [Single Plane A4C, AutoBiplane], HR [Single Plane A4C, AutoBiplane]

Measured by: R-R [2DCALIPER], A4C [2DAUTOVOLUME]

CI MOD A4C [Single Plane A4C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (({LVEDV MOD A4C}-{LVESV MOD A4C})*{HR}/60)/{BSA}

Needs measurement: LVEDV MOD A4C [Single Plane A4C], LVESV MOD A4C [Single Plane A4C], HR [Single Plane A4C]

Measured by: LVESV A4C [2DVOLUMETRACE]

CI MOD LAX [Single Plane LAX, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D:Trace Formula: (({LVEDV MOD LAX}-{LVESV MOD LAX})*{HR}/60)/{BSA} Needs measurement: LVEDV MOD LAX [Single Plane LAX, AutoBiplane], LVESV MOD LAX [Single Plane LAX, AutoBiplane], HR [Single Plane LAX, AutoBiplane] Measured by: R-R [2DCALIPER], AutoVolume [2DAUTOVOLUME]
CI mod sim [Modified Simpson] Mode: 2D:CF:TT:SI:SRI:VR2D:Trace Formula: ((d-s)*{ECG/HeartRate}/60)/{BSA} where: s = ({LVLs(apical)}/9)*((4*{LVAs(sax MV)})+(2*{LVAs(sax PM)})+sqrt({LVAs(sax MV)}*{LVAs(sax PM)})) d = ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM})) Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson], LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson], HR [Modified Simpson] Measured by: R-R [2DCALIPER]
CI(Cube) [Dimension, Cube/Teicholz] Mode: 2D:CF:TT:SI:SRI:VR2D:Trace Formula: ((d-s)*{ECG/HeartRate}/60)/{BSA} where: s = {2D/LVIDs}^3 d = {LVIDd}^3 Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz], HR [Dimension, Cube/Teicholz] Measured by: R-R [2DCALIPER]
CI(Cube) [Generic, Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: ((dv-sv)*{MM/HeartRate}/60)/{BSA} where: sv = {MM/LVIDs}^3 dv = {LVIDd}^3 Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension], HR [Generic, Dimension] Measured by: Heartrate [MMTIMECALIPER]
CI(Teich) [Dimension, Cube/Teicholz] Mode: 2D:CF:TT:SI:SRI:VR2D:Trace Formula: ((d-s)*{ECG/HeartRate}/60)/{BSA} where: s = 7/(2.4+{2D/LVIDs})*{2D/LVIDs}^3 d = 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz], HR [Dimension, Cube/Teicholz] Measured by: R-R [2DCALIPER]
CI(Teich) [Generic, Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: ((dv-sv)*{MM/HeartRate}/60)/{BSA} where: sv = 7/(2.4+{MM/LVIDs})*{MM/LVIDs}^3 dv = 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension], HR [Generic, Dimension] Measured by: Heartrate [MMTIMECALIPER]

CO A-L A2C [Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV A-L A2C}-{LVESV A-L A2C})*{HR}/60

Needs measurement: LVEDV A-L A2C [Single Plane A2C, AutoBiplane], LVESV A-L A2C [Single Plane A2C, AutoBiplane], HR [Single Plane A2C, AutoBiplane]

Measured by: R-R [2DCALIPER], A2C [2DAUTOVOLUME]

CO A-L A2C [Single Plane A2C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L A2C}-{LVESV A-L A2C})*{HR}/60

Needs measurement: LVEDV A-L A2C [Single Plane A2C], LVESV A-L A2C [Single Plane A2C], HR [Single Plane A2C]

Measured by: LVESV A2C [2DVOLUMETRACE]

CO A-L A4C [Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV A-L A4C}-{LVESV A-L A4C})*{HR}/60

Needs measurement: LVEDV A-L A4C [Single Plane A4C, AutoBiplane], LVESV A-L A4C [Single Plane A4C, AutoBiplane], HR [Single Plane A4C, AutoBiplane]

Measured by: R-R [2DCALIPER], A4C [2DAUTOVOLUME]

CO A-L A4C [Single Plane A4C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L A4C}-{LVESV A-L A4C})*{HR}/60

Needs measurement: LVEDV A-L A4C [Single Plane A4C], LVESV A-L A4C [Single Plane A4C], HR [Single Plane A4C]

Measured by: LVESV A4C [2DVOLUMETRACE]

CO A-L LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV A-L LAX}-{LVESV A-L LAX})*{HR}/60

Needs measurement: LVEDV A-L LAX [Single Plane LAX, AutoBiplane], LVESV A-L LAX [Single Plane LAX, AutoBiplane], HR [Single Plane LAX, AutoBiplane]

Measured by: R-R [2DCALIPER], AutoVolume [2DAUTOVOLUME]

CO A-L LAX [Single Plane LAX]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L LAX}-{LVESV A-L LAX})*{HR}/60

Needs measurement: LVEDV A-L LAX [Single Plane LAX], LVESV A-L LAX [Single Plane LAX], HR [Single Plane LAX]

Measured by: LVESV LAX [2DVOLUMETRACE]

CO Biplane [Biplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: d = biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks})

Needs measurement: LVLd A4C [Biplane], LVLd A2C [Biplane], LVLs A4C [Biplane], LVLs A2C [Biplane], HR [Biplane]

Measured by: R-R [2DCALIPER]

CO bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (d-s)*{ECG/HeartRate}/60 where: s = (8/(3*3.14159))*{LVAs(A4C)}*{LVAs(sax MV)}/{2D/LVIDs} d = (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse], LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse], HR [Biplane Ellipse]

Measured by: R-R [2DCALIPER]

CO bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (d-s)*{ECG/HeartRate}/60 where: s =5/6*{LVAs(sax)}*{LVLs(apical)} d = 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet], LVLs apical [Bullet], HR [Bullet]

Measured by: R-R [2DCALIPER]

CO MOD A2C [Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV MOD A2C}-{LVESV MOD A2C})*{HR}/60

Needs measurement: LVEDV MOD A2C [Single Plane A2C, AutoBiplane], LVESV MOD A2C [Single Plane A2C, AutoBiplane], HR [Single Plane A2C, AutoBiplane]

Measured by: R-R [2DCALIPER], A2C [2DAUTOVOLUME]

CO MOD A2C [Single Plane A2C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A2C}-{LVESV MOD A2C})*{HR}/60

Needs measurement: LVEDV MOD A2C [Single Plane A2C], LVESV MOD A2C [Single Plane A2C], HR [Single Plane A2C]

Measured by: LVESV A2C [2DVOLUMETRACE]

CO MOD A4C [Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV MOD A4C}-{LVESV MOD A4C})*{HR}/60

Needs measurement: LVEDV MOD A4C [Single Plane A4C, AutoBiplane], LVESV MOD A4C [Single Plane A4C, AutoBiplane], HR [Single Plane A4C, AutoBiplane]

Measured by: R-R [2DCALIPER], A4C [2DAUTOVOLUME]

CO MOD A4C [Single Plane A4C]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A4C}-{LVESV MOD A4C})*{HR}/60

Needs measurement: LVEDV MOD A4C [Single Plane A4C], LVESV MOD A4C [Single Plane A4C], HR [Single Plane A4C]

Measured by: LVESV A4C [2DVOLUMETRACE]

CO MOD LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: ({LVEDV MOD LAX}-{LVESV MOD LAX})*{HR}/60

Needs measurement: LVEDV MOD LAX [Single Plane LAX, AutoBiplane], LVESV MOD LAX [Single Plane LAX, AutoBiplane], HR [Single Plane LAX, AutoBiplane]

Measured by: R-R [2DCALIPER], AutoVolume [2DAUTOVOLUME]

CO MOD LAX [Single Plane LAX]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD LAX}-{LVESV MOD LAX})*{HR}/60

Needs measurement: LVEDV MOD LAX [Single Plane LAX], LVESV MOD LAX [Single Plane LAX], HR [Single Plane LAX]

Measured by: LVESV LAX [2DVOLUMETRACE]

CO mod sim [Modified Simpson]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (d-s)*{ECG/HeartRate}/60 where: s = ({LVLs(apical)}/9)*((4*{LVAs(sax MV)})+(2*{LVAs(sax d = ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM}))

Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson], LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson], HR [Modified Simpson]

Measured by: R-R [2DCALIPER]

CO(A-L) [Generic]

Mode: 2D:CF:TT:SI:SRI:Trace

Formula: ({EDV(A-L)}-{ESV(A-L)})*{HR}/60

Needs measurement: ESV(A-L) [Generic], HR [Generic]

Measured by: R-R [2DCALIPER]

CO(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (d-s)*{ECG/HeartRate}/60 where: s = {2D/LVIDs}^3 d = {LVIDd}^3

Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz], HR [Dimension, Cube/Teicholz]

Measured by: R-R [2DCALIPER]

CO(Cube) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (dv-sv)*{MM/HeartRate}/60 where: sv = {MM/LVIDs}^3 dv = {LVIDd}^3

Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension], HR [Generic, Dimension]

Measured by: Heartrate [MMTIMECALIPER]

CO(Teich) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D:Trace

Formula: (d-s)*{ECG/HeartRate}/60 where: s = 7/(2.4+{2D/LVIDs})*{2D/LVIDs}^3 d = 7/(2.4+{LVIDd})*{LVIDd}^3

Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz], HR [Dimension, Cube/Teicholz]

Measured by: R-R [2DCALIPER]

CO(Teich) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (dv-sv)*{MM/HeartRate}/60 where: sv = 7/(2.4+{MM/LVIDs})*{MM/LVIDs}^3 dv = 7/(2.4+{LVIDd})*{LVIDd}^3

Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension], HR [Generic, Dimension]

Measured by: Heartrate [MMTIMECALIPER]

EDV bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse]

Measured by: LVEF BP-EL [AUTOCALC]

EDV bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet]

Measured by: LVEF Bullet [AUTOCALC]

EDV mod sim [Modified Simpson]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM}))

Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson]

Measured by: EF mod sim [AUTOCALC]

EDV(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVIDd}^3

Needs measurement: LVIDd [Dimension, Cube/Teicholz]

Measured by: LVd [2DLV], LVIDd [2DCALIPER], EF(Cube) [AUTOCALC]

EDV(Cube) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: {LVIDd}^3

Needs measurement: LVIDd [Generic, Dimension]

Measured by: LV Study [MMLV], LVIDd [MMDISCALIPER]

EDV(Teich) [Dimension, Cube/Teicholz] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Dimension, Cube/Teicholz] Measured by: LVd [2DLV], LVIDd [2DCALIPER], EF(Cube) [AUTOCALC]
EDV(Teich) [Generic, Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Generic, Dimension] Measured by: LV Study [MMLV], LVIDd [MMDISCALIPER]
EF A-L A2C [Biplane, Single Plane A2C, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: ({LVEDV A-L A2C}-{LVESV A-L A2C})/{LVEDV A-L A2C} Needs measurement: LVEDV A-L A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV A-L A2C [Biplane, Single Plane A2C, AutoBiplane] Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]
EF A-L A4C [Biplane, Single Plane A4C, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: ({LVEDV A-L A4C}-{LVESV A-L A4C})/{LVEDV A-L A4C} Needs measurement: LVEDV A-L A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV A-L A4C [Biplane, Single Plane A4C, AutoBiplane] Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]
EF A-L LAX [Single Plane LAX, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: ({LVEDV A-L LAX}-{LVESV A-L LAX})/{LVEDV A-L LAX} Needs measurement: LVEDV A-L LAX [Single Plane LAX, AutoBiplane], LVESV A-L LAX [Single Plane LAX, AutoBiplane] Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]
EF Biplane [Biplane, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: d = biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks}) Needs measurement: LVLd A4C [Biplane, AutoBiplane], LVLd A2C [Biplane, AutoBiplane], LVLs A4C [Biplane, AutoBiplane], LVLs A2C [Biplane, AutoBiplane] Measured by: EF Biplane [AUTOCALC]
EF mod sim [Modified Simpson] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM})) Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson], LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson] Measured by: EF mod sim [AUTOCALC]

EF(A-L) [Generic]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: ({EDV(A-L)}-{ESV(A-L)})/{EDV(A-L)}
Needs measurement: ESV(A-L) [Generic], EDV(A-L) [Generic]
Measured by: EF Volume [AUTOCALC]

EF(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: (d-s)/d where: s = {2D/LVIDs}^3 d = {LVIDd}^3
Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz]
Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

EF(Cube) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: (dv-sv)/dv where: sv = {MM/LVIDs}^3 dv = {LVIDd}^3
Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension]
Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

EF(MOD) [Generic]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: ({EDV(MOD)}-{ESV(MOD)})/{EDV(MOD)}
Needs measurement: EDV(MOD) [Generic], ESV(MOD) [Generic]
Measured by: EF Volume [AUTOCALC]

EF(Teich) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: (d-s)/d where:s = 7/(2.4+{2D/LVIDs})*{2D/LVIDs}^3 d = 7/(2.4+{LVIDd})*{LVIDd}^3
Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz]
Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

EF(Teich) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: (dv-sv)/dv where: sv = 7/(2.4+{MM/LVIDs})*{MM/LVIDs}^3 dv = 7/(2.4+{LVIDd})*{LVIDd}^3
Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension]
Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

ESV bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: (8/(3*3.14159))*{LVAs A4C}*{LVAs sax MV}/{LVIDs}
Needs measurement: LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse]
Measured by: LVEF BP-EL [AUTOCALC]

ESV bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: 5/6*{LVAs sax)}*{LVLs apical}
Needs measurement: LVAs sax) [Bullet], LVLs apical [Bullet]
Measured by: LVEF Bullet [AUTOCALC]

ESV mod sim [Modified Simpson]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVLs apical}/9)*((4*{LVAs sax MV})+(2*{LVAs sax PM})+sqrt({LVAs sax MV}*{LVAs sax PM}))

Needs measurement: LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson]

Measured by: EF mod sim [AUTOCALC]

ESV(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVIDs}^3

Needs measurement: LVIDs [Dimension, Cube/Teicholz]

Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

ESV(Cube) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: {LVIDs}^3

Needs measurement: LVIDs [Generic, Dimension]

Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

ESV(Teich) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: 7/(2.4+{LVIDs})*{LVIDs}^3

Needs measurement: LVIDs [Dimension, Cube/Teicholz]

Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

ESV(Teich) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: 7/(2.4+{LVIDs})*{LVIDs}^3

Needs measurement: LVIDs [Generic, Dimension]

Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

HR (Generic, Dimension, Biplane, Modified Simpson, Cube/Teicholz, Single Plane A4C, Single Plane A2C, Single Plane LAX, Bullet, Biplane Ellipse)

Mode: 2D:CF:TT:SI:SRI:Trace:VR2D

Formula: 60/{R-R}

Needs measurement: R-R [Generic, Dimension, Biplane, Modified Simpson, Cube/Teicholz, Single Plane A4C, Single Plane A2C, Single Plane LAX, Bullet, Biplane Ellipse]

Measured by: R-R [2DCALIPER]

Used to calculate: CO(A-L),CO(Teich),CI(Teich),CO(Cube),CI(Cube),CO Biplane,CI Biplane,CO mod sim,CI mod sim,CI A-L A4C,CO MOD A4C,CI MOD A4C,CI A-L A2C,CO A-L A2C,CI A-L A2C,CO MOD A2C,CI MOD A2C,CO A-L LAX,CI A-L LAX,CO MOD LAX,CI MOD LAX,CO bullet,CI bullet,CO bp el,CI bp el

HR [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: 60/{Time}

Needs measurement: Time [Generic, Dimension]

Measured by: Heartrate [MMTIMECALIPER]

Used to calculate: CO(Cube),CO(Teich),CI(Teich),CI(Cube)

HR [Generic]
Mode: CW:PW:VRCW:VRPW
Formula: 60/{Time}
Needs measurement: Time [Generic]
Measured by: Heartrate [SDTIMECALIPER]

IVSd/LVPWd [Dimension]
Mode: MM:CM:AMM:CAMM:VRMM
Formula: {IVSd}/{LVPWd}
Needs measurement: IVSd [Dimension], LVPWd [Dimension]
Measured by: LVPWd [MMDISCALIPER]

LA/Ao [Generic, Dimension]
Mode: MM:CM:AMM:CAMM:VRMM
Formula: {LA Diam}/{Ao Diam}
Needs measurement: LA Diam [Generic, Dimension], Ao Diam [Generic, Dimension]
Measured by: LA/Ao [MMLAAO]

LIMP [Mitral Valve, Aortic]
Mode: CW:PW:VRCW:VRPW
Formula: ({MCO}-{AVET})/{AVET}
Needs measurement: MCO [Mitral Valve, Aortic], AVET [Mitral Valve, Aortic]
Measured by: LIMP [AUTOCALC]

LVCI Dopp [Aortic]
Mode: PW:VRPW
Formula: ({LVOT Diam}^2*0.785*{LVOT VTI}*{HR}/60)/{BSA}
Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic], HR [Aortic],
Measured by: LVOT Trace [SDMANTRACE]

LVCO Dopp [Aortic]
Mode: PW:VRPW
Formula: {LVOT Diam}^2*0.785*{LVOT VTI}*{HR}/60
Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic], HR [Aortic]
Measured by: LVOT Trace [SDMANTRACE]

LVd Mass (ASE) [Generic]
Mode: MM:CM:AMM:CAMM:VRMM
Formula: ((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))*0.8+0.6)/1000
Needs measurement: IVSd [Generic], LVIDd [Generic], LVPWd [Generic]
Measured by: LV Study [MMLV]

LVd Mass [Dimension]
Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: ((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))-13.6)/1000
Needs measurement: IVSd [Dimension], LVIDd [Dimension], LVPWd [Dimension], LVIDd [Dimension]
Measured by: LVPWd [2DCALIPER]

LVd Mass [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: ((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))-13.6)/1000

Needs measurement: IVSd [Generic, Dimension], LVPWd [Generic, Dimension], LVIDd [Generic, Dimension]

Measured by: LV Study [MMLV], LVPWs [MMDISCALIPER]

LVd Mass A-L [Mass]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: 1.05*5/6*({LVAd(sax epi)}*({LVLd(apical)}+t)-{LVAd(sax PM)}*{LVLd(apical)})/1000 where: t = sqrt({LVAd sax EPI}/3.14159)-sqrt({LVAd sax PM}/3.14159)

Needs measurement: LVAd sax EPI [Mass], LVAd sax PM [Mass], LVLd apical [Mass]

Measured by: LVMass(d) [AUTOCALC]

LVd Mass I A-L [Mass]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: m/{BSA} where: m = 1.05*5/6*({LVAd(sax epi)}*({LVLd(apical)}+t)-{LVAd(sax PM)}*{LVLd(apical)})/1000 t = sqrt({LVAd sax EPI}/3.14159)-sqrt({LVAd sax PM}/3.14159)

Needs measurement: LVAd sax EPI [Mass], LVAd sax PM [Mass], LVLd apical [Mass]

Measured by: LVMass(d) [AUTOCALC]

LVd Mass Ind (ASE) [Generic]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))*0.8+0.6)/1000)/{BSA}

Needs measurement: IVSd [Generic], LVIDd [Generic], LVPWd [Generic]

Measured by: LV Study [MMLV]

LVd Mass Index [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: m/{BSA} where m = ((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))-13.6)/1000

Needs measurement: IVSd [Dimension], LVIDd [Dimension], LVPWd [Dimension], LVIDd [Dimension]

Measured by: LVPWd [2DCALIPER]

LVd Mass Index [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (((1.04*(({IVSd}+{LVIDd}+{LVPWd})^3-({LVIDd})^3))-13.6)/1000)/{BSA}

Needs measurement: IVSd [Generic, Dimension], LVIDd [Generic, Dimension], LVPWd [Generic, Dimension]

Measured by: LV Study [MMLV], LVPWs [MMDISCALIPER]

LVEDV MOD BP [Biplane, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks})

Needs measurement: LVLd A4C [Biplane, AutoBiplane], LVLd A2C [Biplane, AutoBiplane]

Measured by: EF Biplane [AUTOCALC]

LVEF BP-EL [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (d-s)/d where: s = (8/(3*3.14159))*{LVAs(A4C)}*{LVAs(sax MV)}/{2D/LVIDs} d = (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse], LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse]

Measured by: LVEF BP-EL [AUTOCALC]

LVEF Bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (d-s)/d where: s =5/6*{LVAs(sax)}*{LVLs(apical)} d = 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet], LVLs apical [Bullet]

Measured by: LVEF Bullet [AUTOCALC]

LVEF MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A2C}-{LVESV MOD A2C})/{LVEDV MOD A2C}

Needs measurement: LVEDV MOD A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]

LVEF MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A4C}-{LVESV MOD A4C})/{LVEDV MOD A4C}

Needs measurement: LVEDV MOD A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]

LVEF MOD LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD LAX}-{LVESV MOD LAX})/{LVEDV MOD LAX}

Needs measurement: LVEDV MOD LAX [Single Plane LAX, AutoBiplane], LVESV MOD LAX [Single Plane LAX, AutoBiplane]

Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]

LVESV MOD BP [Biplane, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: biplane({LVLs A4C},{LVDisks},{LVLs A2C},{LVDisks})

Needs measurement: LVLs A4C [Biplane, AutoBiplane], LVLs A2C [Biplane, AutoBiplane]

Measured by: EF Biplane [AUTOCALC]

LVIDd Index [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVIDd}/{BSA}

Needs measurement: LVIDd [Dimension],

Measured by: LVIDd [2DCALIPER]

LVIDd Index [Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: {LVIDd}/{BSA} Needs measurement: LVIDd [Dimension] Measured by: LVIDd [MMDISCALIPER]
LVIDs Index [Dimension] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: {LVIDs}/{BSA} Needs measurement: LVIDs [Dimension] Measured by: LVIDs [2DCALIPER]
LVIDs Index [Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: {LVIDs}/{BSA} Needs measurement: LVIDs [Dimension] Measured by: LVIDs [MMDISCALIPER]
LVOT Area [Dimension] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: 3.14/4*{LVOT Diam}^2 Needs measurement: LVOT Diam [Dimension] Measured by: LVOT Diam [2DCALIPER]
LVOT Diam [Aortic] Mode: CW:PW:VRCW:VRPW Formula: {LVOT Diam} Needs measurement: LVOT Diam [Aortic] Measured by: AP Area [SDMANTRACE] Used to calculate: AP Area
LVOT Diam [Mitral Valve] Mode: CW:PW:VRCW:VRPW Formula: {LVOT Diam} Needs measurement: LVOT Diam [Mitral Valve] Measured by: MP Area [SDMANTRACE] Used to calculate: MP Area
LVOT VTI [Aortic] Mode: CW:PW:VRCW:VRPW Formula: {LVOT VTI} Needs measurement: LVOT VTI [Aortic] Measured by: AP Area [SDMANTRACE] Used to calculate: AP Area

LVOT VTI [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {LVOT VTI}
Needs measurement: LVOT VTI [Mitral Valve]
Measured by: MP Area [SDMANTRACE]
Used to calculate: MP Area

LVPEP/ET [Aortic]

Mode: CW:PW:VRCW:VRPW
Formula: {LVPEP}/{LVET}
Needs measurement: LVPEP [Aortic], LVET [Aortic]
Measured by: LVET [SDTIMECALIPER]

LVPEP/ET [Time]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: {LVPEP}/{LVET}
Needs measurement: LVPEP [Time], LVET [Time]
Measured by: LVET [MMTIMECALIPER]

LVs Mass (ASE) [Generic]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: ((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))*0.8+0.6)/1000
Needs measurement: IVSs [Generic], LVIDs [Generic], LVPWs [Generic]
Measured by: LV Study [MMLV]

LVs Mass [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: ((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))-13.6)/1000
Needs measurement: IVSs [Dimension], LVIDs [Dimension], LVPWs [Dimension]
Measured by: LVPWs [2DCALIPER]

LVs Mass [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: ((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))-13.6)/1000
Needs measurement: IVSs [Generic, Dimension], LVIDs [Generic, Dimension], LVPWs [Generic, Dimension]
Measured by: LV Study [MMLV], LVPWs [MMDISCALIPER]

LVs Mass A-L [Mass]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: 1.05*5/6*({LVAs(sax epi)}*({LVLs(apical)}+t)-{LVAs(sax PM)}*{LVLs(apical)})/1000 where: t = sqrt({LVAs sax EPI}/3.14159)-sqrt({LVAs sax PM}/3.14159)
Needs measurement: LVAs sax EPI [Mass], LVAs sax PM [Mass], LVLs apical [Mass]
Measured by: LVMass(s) [AUTOCALC]

LVs Mass Ind (ASE) [Generic]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))*0.8+0.6)/1000)/{BSA}

Needs measurement: IVSs [Generic], LVIDs [Generic], LVPWs [Generic]

Measured by: LV Study [MMLV]

LVs Mass Ind A-L [Mass]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: m/{BSA} where: m = 1.05*5/6*({LVAs(sax epi)}*({LVLs(apical)}+t)-{LVAs(sax PM)}*{LVLs(apical)})/1000 t = sqrt({LVAs sax EPI}/3.14159)-sqrt({LVAs sax PM}/3.14159)

Needs measurement: LVAs sax EPI [Mass], LVAs sax PM [Mass], LVLs apical [Mass]

Measured by: LVMass(s) [AUTOCALC]

LVs Mass Index [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: m/{BSA} where: m = ((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))-13.6)/1000

Needs measurement: IVSs [Dimension], LVIDs [Dimension], LVPWs [Dimension]

Measured by: LVPWs [2DCALIPER]

LVs Mass Index [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: (((1.04*(({IVSs}+{LVIDs}+{LVPWs})^3-({LVIDs})^3))-13.6)/1000)/{BSA}

Needs measurement: IVSs [Generic, Dimension], LVIDs [Generic, Dimension], LVPWs [Generic, Dimension]

Measured by: LV Study [MMLV], LVPWs [MMDISCALIPER]

LVSI Dopp [Aortic]

Mode: PW:VRPW

Formula: {LVOT Diam}^2*0.785*{LVOT VTI}/{BSA}

Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic],

Measured by: LVOT Trace [SDMANTRACE]

LVSV Dopp [Aortic]

Mode: PW:VRPW

Formula: {LVOT Diam}^2*0.785*{LVOT VTI}

Needs measurement: LVOT Diam [Aortic], LVOT VTI [Aortic]

Measured by: LVOT Trace [SDMANTRACE]

MP Area [Mitral Valve]

Mode: CW:PW:VRCW:VRPW

Formula: {LVOT Diam}^2*0.785*({LVOT VTI}/{MP VTI})

Needs measurement: LVOT Diam [Mitral Valve], LVOT VTI [Mitral Valve], MP VTI [Mitral Valve]

Measured by: MP Area [SDMANTRACE]

MR ERO [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {MR Flow}/{MR Vmax}
Needs measurement: MR Flow [PISA], MR Vmax [PISA]
Measured by: MR Trace [AUTOCALC]

MR RV [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {MR Flow}/{MR Vmax}*{MR VTI}
Needs measurement: MR Flow [PISA], MR Vmax [PISA], MR VTI [PISA]
Measured by: MR Trace [AUTOCALC]

MV AccT/DecT [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV AccT}/{MV DecT}
Needs measurement: MV AccT [Mitral Valve], MV DecT [Mitral Valve]
Measured by: MV AccT [SDCALIPER]

MV Area [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: 3.14/4*{MV Ann Diam}^2
Needs measurement: MV Ann Diam [Dimension]
Measured by: MV Ann Diam [2DCALIPER]

MV CI [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV Ann Diam}^2*0.785*{MV VTI}*{HR}/60/{BSA}
Needs measurement: MV Ann Diam [Mitral Valve], MV VTI [Mitral Valve], HR [Mitral Valve]
Measured by: MV Trace [SDMANTRACE]

MV CO [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV Ann Diam}^2*0.785*{MV VTI}*{HR}/60
Needs measurement: MV Ann Diam [Mitral Valve], MV VTI [Mitral Valve], HR [Mitral Valve]
Measured by: MV Trace [SDMANTRACE]

MV E/A Ratio [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV E Vel}/{MV A Vel}
Needs measurement: MV E Vel [Mitral Valve], MV A Vel [Mitral Valve]
Measured by: MV A Vel [SDPTCALIPER], MV A Vel [AUTOCALC]

MV SI [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV Ann Diam}^2*0.785*{MV VTI}/{BSA}
Needs measurement: MV Ann Diam [Mitral Valve], MV VTI [Mitral Valve],
Measured by: MV Trace [SDMANTRACE]

MV SV [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {MV Ann Diam}^2*0.785*{MV VTI}
Needs measurement: MV Ann Diam [Mitral Valve], MV VTI [Mitral Valve]
Measured by: MV Trace [SDMANTRACE]

MVA (VTI) [Mitral Valve]

Mode: 2D:CW:PW:VRCW:VRPW
Formula: 3.14/4*{LVOT Diam}^2*{LVOT VTI}/{MV VTI}
Needs measurement: LVOT Diam [Mitral Valve], LVOT VTI [Mitral Valve], MV VTI [Mitral Valve]
Measured by: MV Trace [AUTOCALC]

MVA By PHT [Mitral Valve]

Mode: CW:PW:VRCW:VRPW
Formula: 22/({MV PHT})
Needs measurement: MV PHT [Mitral Valve]
Measured by: MV E/A Velocity [SDEA3], MV PHT [SDCALIPER]

P Vein S/D Ratio [Pulmonary Vein]

Mode: PW:VRPW
Formula: {P Vein S}/{P Vein D}
Needs measurement: P Vein S [Pulmonary Vein], P Vein D [Pulmonary Vein]
Measured by: P Vein D [SDPTCALIPER]

PAEDP [Pulmonic]

Mode: CW:PW:VRCW:VRPW
Formula: {PRend PG}+{RAP}
Needs measurement: PRend PG [Pulmonic], RAP [Pulmonic]
Measured by: PRend Vmax [AUTOCALC]

PR ERO [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {PR Flow}/{PR Vmax}
Needs measurement: PR Flow [PISA], PR Vmax [PISA]
Measured by: PR Trace [AUTOCALC]

PR RV [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {PR Flow}/{PR Vmax}*{PR VTI}
Needs measurement: PR Flow [PISA], PR Vmax [PISA], PR VTI [PISA]
Measured by: PR Trace [AUTOCALC]

Pulmonic CO [Shunts, Congenital Heart]

Mode: CW:PW:VRCW:VRPW
Formula: {Pulmonic SV}*{Pulmonic HR}/60
Needs measurement: Pulmonic SV [Shunts, Congenital Heart], Pulmonic HR [Shunts, Congenital Heart]
Measured by: Pulmonic VTI [SDMANTRACE]

Pulmonic SV [Shunts, Congenital Heart]

Mode: CW:PW:VRCW:VRPW

Formula: 3.14159/4*{Pulmonic Diam}^2*{Pulmonic VTI}

Needs measurement: Pulmonic Diam [Shunts, Congenital Heart], Pulmonic VTI [Shunts, Congenital Heart]

Measured by: Pulmonic VTI [SDMANTRACE], Pulmonic VTI [SDMANTRACE]

Used to calculate: Pulmonic CO

PV A/MV A Dur [Pulmonary Vein]

Mode: PW:VRPW

Formula: {P Vein A Dur}/{MV A Dur}

Needs measurement: P Vein A Dur [Pulmonary Vein], MV A Dur [Pulmonary Vein]

Measured by: P Vein A Dur [SDTIMECALIPER]

PV A/MV VTI [Pulmonary Vein]

Mode: PW:VRPW

Formula: {P Vein A Dur}/{MV VTI}

Needs measurement: P Vein A Dur [Pulmonary Vein], MV VTI [Pulmonary Vein]

Measured by: P Vein A Dur [SDTIMECALIPER]

PV AccT/ET [Pulmonic]

Mode: CW:PW:VRCW:VRPW

Formula: {PV AccT}/{PVET}

Needs measurement: PV AccT [Pulmonic], PVET [Pulmonic]

Measured by: PVET [SDTIMECALIPER]

PV A-MV A Dur [Pulmonary Vein]

Mode: PW:VRPW

Formula: {P Vein A Dur}-{MV A Dur}

Needs measurement: P Vein A Dur [Pulmonary Vein], MV A Dur [Pulmonary Vein]

Measured by: P Vein A Dur [SDTIMECALIPER]

PV Area [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: 3.14/4*{PV Ann Diam}^2

Needs measurement: PV Ann Diam [Dimension]

Measured by: PV Ann Diam [2DCALIPER]

PV CI [Pulmonic, Valvular PS]

Mode: CW:PW:VRCW:VRPW

Formula: (({PV Ann Diam}^2*0.785*{PV VTI})*{HR}/60)/{BSA}

Needs measurement: PV Ann Diam [Pulmonic, Valvular PS], PV VTI [Pulmonic, Valvular PS], HR [Pulmonic, Valvular PS]

Measured by: PV Trace [SDMANTRACE]

PV CO [Pulmonic, Valvular PS] Mode: CW:PW:VRCW:VRPW Formula: ({PV Ann Diam}^2*0.785*{PV VTI})*{HR}/60 Needs measurement: PV Ann Diam [Pulmonic, Valvular PS], PV VTI [Pulmonic, Valvular PS], HR [Pulmonic, Valvular PS] Measured by: PV Trace [SDMANTRACE]
PV SI [Pulmonic, Valvular PS] Mode: CW:PW:VRCW:VRPW Formula: ({PV Ann Diam}^2*0.785*{PV VTI})/{BSA} Needs measurement: PV Ann Diam [Pulmonic, Valvular PS], PV VTI [Pulmonic, Valvular PS] Measured by: PV Trace [SDMANTRACE]
PV SV [Pulmonic, Valvular PS] Mode: CW:PW:VRCW:VRPW Formula: {PV Ann Diam}^2*0.785*{PV VTI} Needs measurement: PV Ann Diam [Pulmonic, Valvular PS], PV VTI [Pulmonic, Valvular PS] Measured by: PV Trace [SDMANTRACE]
PVA (Vmax) [Pulmonic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT Vmax}/{PV Vmax} Needs measurement: RVOT Diam [Pulmonic], RVOT Vmax [Pulmonic], PV Vmax [Pulmonic] Measured by: PV Vmax [AUTOCALC]
PVA (Vmax) [Pulmonic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT Vmax}/{PV Vmax} Needs measurement: RVOT Diam [Pulmonic], RVOT Vmax [Pulmonic], PV Vmax [Pulmonic] Measured by: PV Trace [AUTOCALC]
PVA (VTI) [Pulmonic] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT VTI}/{PV VTI} Needs measurement: RVOT Diam [Pulmonic], RVOT VTI [Pulmonic], PV VTI [Pulmonic] Measured by: PV Trace [AUTOCALC]
Qp/Qs [Shunts, Congenital Heart] Mode: CW:PW:VRCW:VRPW Formula: 3.14159/4*{Pulmonic Diam}^2*{Pulmonic VTI}/(3.14159/4*{Systemic Diam}^2*{Systemic VTI}) Needs measurement: Pulmonic Diam [Shunts, Congenital Heart], Pulmonic VTI [Shunts, Congenital Heart], Systemic Diam [Shunts, Congenital Heart], Systemic VTI [Shunts, Congenital Heart] Measured by: Qp/Qs [AUTOCALC]

RIMP [Pulmonic, Tricuspid Valve]

Mode: CW:PW:VRCW:VRPW

Formula: ({TCO}-{PVET})/{PVET}

Needs measurement: TCO [Pulmonic, Tricuspid Valve], PVET [Pulmonic, Tricuspid Valve], PVET [Pulmonic, Tricuspid Valve]

Measured by: RIMP [AUTOCALC]

RVOT Area [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: 3.14/4*{RVOT Diam}^2

Needs measurement: RVOT Diam [Dimension]

Measured by: RVOT Diam [2DCALIPER]

RVOT CI [Pulmonic, Valvular PS]

Mode: PW:VRPW

Formula: (({RVOT Diam}^2*0.785*{RVOT VTI})*{HR}/60)/{BSA}

Needs measurement: RVOT Diam [Pulmonic, Valvular PS], RVOT VTI [Pulmonic, Valvular PS], HR [Pulmonic, Valvular PS],

Measured by: RVOT Trace [SDMANTRACE]

RVOT CO [Pulmonic, Valvular PS]

Mode: PW:VRPW

Formula: ({RVOT Diam}^2*0.785*{RVOT VTI})*{HR}/60

Needs measurement: RVOT Diam [Pulmonic, Valvular PS], RVOT VTI [Pulmonic, Valvular PS], HR [Pulmonic, Valvular PS]

Measured by: RVOT Trace [SDMANTRACE]

RVOT SI [Pulmonic, Valvular PS]

Mode: PW:VRPW

Formula: ({RVOT Diam}^2*0.785*{RVOT VTI})/{BSA}

Needs measurement: RVOT Diam [Pulmonic, Valvular PS], RVOT VTI [Pulmonic, Valvular PS],

Measured by: RVOT Trace [SDMANTRACE]

RVOT SV [Pulmonic, Valvular PS]

Mode: PW:VRPW

Formula: {RVOT Diam}^2*0.785*{RVOT VTI}

Needs measurement: RVOT Diam [Pulmonic, Valvular PS], RVOT VTI [Pulmonic, Valvular PS]

Measured by: RVOT Trace [SDMANTRACE]

RVPEP/ET [Pulmonic]

Mode: CW:PW:VRCW:VRPW

Formula: {RVPEP}/{RVET}

Needs measurement: RVPEP [Pulmonic], RVET [Pulmonic]

Measured by: RVET [SDTIMECALIPER]

RVPEP/ET [Time]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: {RVPEP}/{RVET}

Needs measurement: RVPEP [Time], RVET [Time]

Measured by: RVET [MMTIMECALIPER]

RVSP [Tricuspid Valve]

Mode: CW:PW:VRCW:VRPW

Formula: {TR maxPG}+{RAP}

Needs measurement: TR maxPG [Tricuspid Valve], RAP [Tricuspid Valve]

Measured by: TR Vmax [AUTOCALC]

SI A-L A2C [Biplane, Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L A2C}-{LVESV A-L A2C})/{BSA}

Needs measurement: LVEDV A-L A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV A-L A2C [Biplane, Single Plane A2C, AutoBiplane]

Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]

SI A-L A4C [Biplane, Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L A4C}-{LVESV A-L A4C})/{BSA}

Needs measurement: LVEDV A-L A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV A-L A4C [Biplane, Single Plane A4C, AutoBiplane]

Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]

SI A-L LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV A-L LAX}-{LVESV A-L LAX})/{BSA}

Needs measurement: LVEDV A-L LAX [Single Plane LAX, AutoBiplane], LVESV A-L LAX [Single Plane LAX, AutoBiplane]

Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]

SI Biplane [Biplane, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: d = biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks})

Needs measurement: LVLd A4C [Biplane, AutoBiplane], LVLd A2C [Biplane, AutoBiplane], LVLs A4C [Biplane, AutoBiplane], LVLs A2C [Biplane, AutoBiplane]

Measured by: EF Biplane [AUTOCALC]

SI bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (d-s)/{BSA} where: s = (8/(3*3.14159))*{LVAs(A4C)}*{LVAs(sax MV)}/{2D/LVIDs} d = (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse], LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse]

Measured by: LVEF BP-EL [AUTOCALC]

SI bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (d-s)/{BSA} where: s =5/6*{LVAs(sax)}*{LVLs(apical)} d = 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet], LVLs apical [Bullet],

Measured by: LVEF Bullet [AUTOCALC]

SI MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A2C}-{LVESV MOD A2C})/{BSA}

Needs measurement: LVEDV MOD A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]

SI MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD A4C}-{LVESV MOD A4C})/{BSA}

Needs measurement: LVEDV MOD A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]

SI MOD LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVEDV MOD LAX}-{LVESV MOD LAX})/{BSA}

Needs measurement: LVEDV MOD LAX [Single Plane LAX, AutoBiplane], LVESV MOD LAX [Single Plane LAX, AutoBiplane]

Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]

SI mod sim [Modified Simpson]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: d-s/{BSA} where: s = ({LVLs(apical)}/9)*((4*{LVAs(sax MV)})+(2*{LVAs(sax PM)})+sqrt({LVAs(sax MV)}*{LVAs(sax PM)})) d = ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM}))

Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson], LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson]

Measured by: EF mod sim [AUTOCALC]

SI(A-L) [Generic]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({EDV(A-L)}-{ESV(A-L)})/{BSA}

Needs measurement: ESV(A-L) [Generic]

Measured by: EF Volume [AUTOCALC]

SI(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: (d-s)/{BSA} where: s = {2D/LVIDs}^3 d = {LVIDd}^3

Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz]

Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

SI(Cube) [Generic] Mode: MM:CM:AMM:CAMM:VRMM Formula: (dv-sv)/{BSA} where: sv = {MM/LVIDs}^3 dv = {LVIDd}^3 Needs measurement: LVIDd [Generic], LVIDs [Generic], Measured by: LV Study [MMLV]
SI(MOD) [Generic] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: ({EDV(MOD)}-{ESV(MOD)})/{BSA} Needs measurement: EDV(MOD) [Generic], ESV(MOD) [Generic] Measured by: EF Volume [AUTOCALC]
SI(Teich) [Dimension, Cube/Teicholz] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: (d-s)/{BSA} s = 7/(2.4+{2D/LVIDs})*{2D/LVIDs}^3 d = 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz] Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]
SI(Teich) [Generic] Mode: MM:CM:AMM:CAMM:VRMM Formula: (dv-sv)/{BSA} where: sv = 7/(2.4+{MM/LVIDs})*{MM/LVIDs}^3 dv = 7/(2.4+{LVIDd})*{LVIDd}^3 Needs measurement: LVIDd [Generic], LVIDd [Generic], LVIDs [Generic] Measured by: LV Study [MMLV]
SV A-L A2C [Biplane, Single Plane A2C, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: {LVEDV A-L A2C}-{LVESV A-L A2C} Needs measurement: LVEDV A-L A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV A-L A2C [Biplane, Single Plane A2C, AutoBiplane] Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]
SV A-L A4C [Biplane, Single Plane A4C, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: {LVEDV A-L A4C}-{LVESV A-L A4C} Needs measurement: LVEDV A-L A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV A-L A4C [Biplane, Single Plane A4C, AutoBiplane] Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]
SV A-L LAX [Single Plane LAX, AutoBiplane] Mode: 2D:CF:TT:SI:SRI:VR2D Formula: {LVEDV A-L LAX}-{LVESV A-L LAX} Needs measurement: LVEDV A-L LAX [Single Plane LAX, AutoBiplane], LVESV A-L LAX [Single Plane LAX, AutoBiplane] Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]

SV Biplane [Biplane, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: d = biplane({LVLd A4C},{LVDisks},{LVLd A2C},{LVDisks})

Needs measurement: LVLd A4C [Biplane, AutoBiplane], LVLd A2C [Biplane, AutoBiplane], LVLs A4C [Biplane, AutoBiplane], LVLs A2C [Biplane, AutoBiplane]

Measured by: EF Biplane [AUTOCALC]

SV bp el [Biplane Ellipse]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: d = (8/(3*3.14159))*{LVAd A4C}*{LVAd (sax MV)}/{LVIDd}

Needs measurement: LVAd A4C [Biplane Ellipse], LVAd (sax MV) [Biplane Ellipse], LVIDd [Biplane Ellipse], LVAs A4C [Biplane Ellipse], LVAs sax MV [Biplane Ellipse], LVIDs [Biplane Ellipse]

Measured by: LVEF BP-EL [AUTOCALC]

SV bullet [Bullet]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: d-s where: s =5/6*{LVAs(sax)}*{LVLs(apical)} d = 5/6*{LVAd sax)}*{LVLd apical}

Needs measurement: LVAd sax) [Bullet], LVLd apical [Bullet], LVLs apical [Bullet]

Measured by: LVEF Bullet [AUTOCALC]

SV MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVEDV MOD A2C}-{LVESV MOD A2C}

Needs measurement: LVEDV MOD A2C [Biplane, Single Plane A2C, AutoBiplane], LVESV MOD A2C [Biplane, Single Plane A2C, AutoBiplane]

Measured by: EF SP A2C [AUTOCALC], LVESV A2C [2DVOLUMETRACE], A2C [2DAUTOVOLUME]

SV MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVEDV MOD A4C}-{LVESV MOD A4C}

Needs measurement: LVEDV MOD A4C [Biplane, Single Plane A4C, AutoBiplane], LVESV MOD A4C [Biplane, Single Plane A4C, AutoBiplane]

Measured by: EF SP A4C [AUTOCALC], LVESV A4C [2DVOLUMETRACE], A4C [2DAUTOVOLUME]

SV MOD LAX [Single Plane LAX, AutoBiplane]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: {LVEDV MOD LAX}-{LVESV MOD LAX}

Needs measurement: LVEDV MOD LAX [Single Plane LAX, AutoBiplane], LVESV MOD LAX [Single Plane LAX, AutoBiplane]

Measured by: LVESV LAX [2DVOLUMETRACE], EF SP LAX [AUTOCALC], AutoVolume [2DAUTOVOLUME]

SV mod sim [Modified Simpson]

Mode: 2D:CF:TT:SI:SRI:VR2D

Formula: ({LVLd apical}/9)*((4*{LVAd (sax MV)})+(2*{LVAd sax PM})+sqrt({LVAd (sax MV)}*{LVAd sax PM}))

Needs measurement: LVLd apical [Modified Simpson], LVAd (sax MV) [Modified Simpson], LVAd sax PM [Modified Simpson], LVLs apical [Modified Simpson], LVAs sax MV [Modified Simpson], LVAs sax PM [Modified Simpson]

Measured by: EF mod sim [AUTOCALC]

SV(A-L) [Generic]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: {EDV(A-L)}-{ESV(A-L)}
Needs measurement: ESV(A-L) [Generic]
Measured by: EF Volume [AUTOCALC]

SV(Cube) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: d-s where: s = {2D/LVIDs}^3 d = {LVIDd}^3
Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz]
Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

SV(Cube) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: dv-sv where: sv = {MM/LVIDs}^3 dv = {LVIDd}^3
Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension]
Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

SV(MOD) [Generic]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: {EDV(MOD)}-{ESV(MOD)}
Needs measurement: EDV(MOD) [Generic], ESV(MOD) [Generic]
Measured by: EF Volume [AUTOCALC]

SV(Teich) [Dimension, Cube/Teicholz]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: d-s where: s = 7/(2.4+{2D/LVIDs})*{2D/LVIDs}^3 d = 7/(2.4+{LVIDd})*{LVIDd}^3
Needs measurement: LVIDd [Dimension, Cube/Teicholz], LVIDs [Dimension, Cube/Teicholz]
Measured by: LVs [2DLV], LVIDs [2DCALIPER], EF(Cube) [AUTOCALC]

SV(Teich) [Generic, Dimension]

Mode: MM:CM:AMM:CAMM:VRMM
Formula: dv-sv where: sv = 7/(2.4+{MM/LVIDs})*{MM/LVIDs}^3 dv = 7/(2.4+{LVIDd})*{LVIDd}^3
Needs measurement: LVIDd [Generic, Dimension], LVIDs [Generic, Dimension]
Measured by: LV Study [MMLV], LVIDs [MMDISCALIPER]

Systemic CO [Shunts, Congenital Heart]

Mode: CW:PW:VRCW:VRPW
Formula: {Systemic SV}*{Systemic HR}/60
Needs measurement: Systemic SV [Shunts, Congenital Heart], Systemic HR [Shunts, Congenital Heart]
Measured by: Systemic VTI [SDMANTRACE]

Systemic SV [Shunts, Congenital Heart]

Mode: CW:PW:VRCW:VRPW
Formula: 3.14159/4*{Systemic Diam}^2*{Systemic VTI}
Needs measurement: Systemic Diam [Shunts, Congenital Heart], Systemic VTI [Shunts, Congenital Heart]
Measured by: Systemic VTI [SDMANTRACE], Systemic VTI [SDMANTRACE]
Used to calculate: Systemic CO

TR ERO [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {TR Flow}/{TR Vmax}
Needs measurement: TR Flow [PISA], TR Vmax [PISA]
Measured by: TR Trace [AUTOCALC]

TR RV [PISA]

Mode: CF:CW:PW:VRCW:VRPW
Formula: {TR Flow}/{TR Vmax}*{TR VTI}
Needs measurement: TR Flow [PISA], TR Vmax [PISA], TR VTI [PISA]
Measured by: TR Trace [AUTOCALC]

TV AccT/DecT [Tricuspid Valve]

Mode: CW:PW:VRCW:VRPW
Formula: {TV AccT}/{TV Dec Time}
Needs measurement: TV AccT [Tricuspid Valve], TV Dec Time [Tricuspid Valve]
Measured by: TV AccT [SDCALIPER]

TV Area [Dimension]

Mode: 2D:CF:TT:SI:SRI:VR2D
Formula: 3.14/4*{TV Ann Diam}^2
Needs measurement: TV Ann Diam [Dimension]
Measured by: TV Ann Diam [2DCALIPER]

TV CI [Tricuspid Valve]

Mode: CW:PW:VRCW:VRPW
Formula: (({TV Ann Diam}^2*0.785*{TV VTI})*{HR}/60)/{BSA}
Needs measurement: TV Ann Diam [Tricuspid Valve], TV VTI [Tricuspid Valve], HR [Tricuspid Valve]
Measured by: TV Trace [SDMANTRACE]

TV CO [Tricuspid Valve]

Mode: CW:PW:VRCW:VRPW
Formula: ({TV Ann Diam}^2*0.785*{TV VTI})*{HR}/60
Needs measurement: TV Ann Diam [Tricuspid Valve], TV VTI [Tricuspid Valve], HR [Tricuspid Valve]
Measured by: TV Trace [SDMANTRACE]

TV E/A Ratio [Tricuspid Valve] Mode: CW:PW:VRCW:VRPW Formula: {TV E Vel}/{TV A Vel} Needs measurement: TV E Vel [Tricuspid Valve], TV A Vel [Tricuspid Valve] Measured by: TV A Vel [SDPTCALIPER]
TV SI [Tricuspid Valve] Mode: CW:PW:VRCW:VRPW Formula: ({TV Ann Diam}^2*0.785*{TV VTI})/{BSA} Needs measurement: TV Ann Diam [Tricuspid Valve], TV VTI [Tricuspid Valve] Measured by: TV Trace [SDMANTRACE]
TV SV [Tricuspid Valve] Mode: CW:PW:VRCW:VRPW Formula: {TV Ann Diam}^2*0.785*{TV VTI} Needs measurement: TV Ann Diam [Tricuspid Valve], TV VTI [Tricuspid Valve] Measured by: TV Trace [SDMANTRACE]
TVA (Vmax) [Tricuspid Valve] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT Vmax}/{TV Vmax} Needs measurement: RVOT Diam [Tricuspid Valve], RVOT Vmax [Tricuspid Valve], TV Vmax [Tricuspid Valve] Measured by: TV Vmax [AUTOCALC]
TVA (Vmax) [Tricuspid Valve] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT Vmax}/{TV Vmax} Needs measurement: RVOT Diam [Tricuspid Valve], RVOT Vmax [Tricuspid Valve], TV Vmax [Tricuspid Valve] Measured by: TV Trace [AUTOCALC]
TVA (VTI) [Tricuspid Valve] Mode: 2D:CW:PW:VRCW:VRPW Formula: 3.14/4*{RVOT Diam}^2*{RVOT VTI}/{TV VTI} Needs measurement: RVOT Diam [Tricuspid Valve], RVOT VTI [Tricuspid Valve], TV VTI [Tricuspid Valve] Measured by: TV Trace [AUTOCALC]
Vcf mean [Dimension] Mode: MM:CM:AMM:CAMM:VRMM Formula: ({LVIDd}-{LVIDs})/({LVIDd}*{LVET}) Needs measurement: LVIDd [Dimension], LVIDs [Dimension], LVET [Dimension] Measured by: Vcf [MMTIMECALIPER]

Vcf mn (corr) [Dimension]

Mode: MM:CM:AMM:CAMM:VRMM

Formula: ({LVIDd}-{LVIDs})/({LVIDd}*({LVET}/sqrt({Time})))

Needs measurement: LVIDd [Dimension], LVIDs [Dimension], LVET [Dimension], Time [Dimension]

Measured by: Vcf [MMTIMECALIPER]

Formulas–Generic

Calc Mnemonic	Calc Name	Input Measurements	Formula
BSA	Body Surface Area	Patient weight (kg) and height (m)	$0.007184 \times Weight^{0.425} \times Height^{0.725}$
BSA	Body Surface Area	Patient weight (kg)	$0.1 \times Weight^{0.667}$
MaxPG	Maximum Pressure Gradient	two Doppler blood flow peak velocities	MaxPG[mmHg]=4x(v1^2-v2^2)
MeanPG	Mean Pressure Gradient	flow velocities from one time marker to another time marker in a Doppler display	MeanPG[mmHg]= $4x \sum_{i=1}^{n} (Vi^2)/n$
% Stenosis	Stenosis Ratio	two areas (by ellipse, trace, circle or distance)	% Stenosis= $[1-(A_{residual}/A_{lumen})]x100$
PI	Pulsatility Index	two Doppler blood flow peak velocities and TAMAX	$PI=(V_{max}-V_{diastole})/TAMAX^a$
RI	Resistivity Index	two Doppler blood flow peak velocities	$RI=(V_{max}-V_{diastole})/V_{max}^a$
HR	Heart Rate (beats/minute)	one 2 beat time interval	HR[BPM]=120[sec]/ 2beat time [sec]
A/B Ratio	Velocities Ratio	two Doppler blood flow peak velocities	$A/B=V_1/V_2$
TAMAX	Time Averaged Maximum Velocity (Trace Method is Peak or manual)	two time marks in a Doppler display	TAMAX=sum{Vt} from t1 to t2/(t2-t1) [cm/s or m/s]
TAMIN	Time Averaged Minimum Velocity (Trace method is Floor)	two time marks in a Doppler display	TAMIN=sum{V_t} from t1 to t2/(t2-t1) [cm/s or m/s]
TAMEAN	Time Averaged Mean Velocity (Trace method is Mean)	two time marks in a Doppler display	TAMEAN=sum{V_t} from t1 to t2/(t2-t1) [cm/s or m/s]

a.Vdiastole = Vmin or Vend-diastole (depends on preset selection)

Calc Name	Input Measurements	Formula
Volume (spherical)	one distance	Vol[ml]=(π/6)xd^3
Volume (prolate spheroidal)	two distances, d1>d2	Vol[ml]= (π/6)xd1xd2^2
Volume (prolate spheroidal)	one ellipse, d1 major axis, d2 minor axis	Vol[ml]= (π/6)xd1xd2^2

Calc Name	Input Measurements	Formula
Volume (spheroidal)	three distances	Vol[ml]= (π/6)xd1xd2xd3
Volume (spheroidal)	one distance d1, one ellipse, d2 ma jor axis, d3 minor axis	Vol[ml]= (π/6)xd1xd2xd3

Formulas–Vascular

Vascular Calculation Formulas

Calc Mnemonic	Calc Name	Input Measurements	Formula
RT ECA	Right External Carotid Artery Velocity	one Doppler blood flow peak velocity	RT ECA=v1 [cm/s or m/s]
RT CCA	Right Common Carotid Artery Velocity	one Doppler blood flow peak velocity	RT CCA=v1 [cm/s or m/s]
RT BIFURC	Right Carotid Bifurcation Velocity	one Doppler blood flow peak velocity	RT BIFURC=v1 [cm/s or m/s]
RT ICA	Right Internal Carotid Artery Velocity	one Doppler blood flow peak velocity	RT ICA=v1 [cm/s or m/s]
RT ICA/CCA	Right Internal Carotid Artery Velocity/Common Carotid Artery Velocity Ratio	two Doppler blood flow peak velocities	RT ICA/CCA=V_{ICA}/ V_{CCA}
LT ECA, LT CCA, LT BIFURC, LT ICA, LT ICA/CCA	Same as above, for Left Carotid Artery	Same as above	Same as above
A/B Ratio	Velocities Ratio	two Doppler blood flow peak velocities	A/B=V_1/V_2
% Stenosis	Stenosis Ratio	two areas (by ellipse, trace, circle or distance)	% Stenosis=[1-($A_{residual}$/ A_{lumen})]x100
S/D Ratio	Systolic Velocity/Diastolic Velocities Ratio	two Doppler blood flow peak velocities	S/D=$V_{systole}$/$V_{diastole}$[a]
PI	Pulsatility Index	two Doppler blood flow peak velocities and TAMAX	PI=(V_{max}-$V_{diastole}$)/ TAMAX[a]
RI	Resistivity Index	two Doppler blood flow peak velocities	RI=(V_{max}-$V_{diastole}$)/ V_{max}[a]
HR	Heart Rate (beats/minute)	one 2 beat time interval (measured manually or automatically)	HR[BPM]=120[sec]/ 2 beat time[sec]

a.$V_{diastole}$ = V_{min} or $V_{end\text{-}diastole}$ (depends on preset selection)

Measurement accuracy

General

When using the Measurement and Analysis (M&A) package, it is important to keep in mind the different aspects that affect the accuracy of the measurements. These include acoustical properties, patient echogenicity, measurement tools and algorithms, scanner setup (especially Field-of-view or Range settings), probe type used, and operator inputs.

Sources of error

Image Quality

The accuracy of each measurement is highly dependent on image quality. Image quality is highly dependent on system design, operator variability, and patient echogenicity. The operator variability and patient echogenicity are independent of the ultrasound system

Operator variability

One of the largest potential sources of error is operator variability. A skilled operator can reduce this by optimizing the image quality for each type of measurement. Clear identification of structures, good probe alignment and correct cursor placement is important. Because of pixel resolution, the accuracy of a measurement decreases with decreasing distance on screen. Therefore it is important when scaling the object on the screen to avoid measuring objects that are too small.

See also "Optimizing Measurement Accuracy" below for recommended techniques.

Image measurement

The accuracy in lateral direction is limited by the beam width and the beam positioning. The radial accuracy is mainly limited by the acoustic pulse length.

Doppler alignment

If alignment is not possible, you may use the Angle Correction control to compensate if the flow direction is known.

Errors in velocity measurements increase with the cosine of the angle between the measured flow and the ultrasound beam. For example, an alignment error of 20 degrees, will give a 6% under-estimation of the velocities, while an error of 40 degrees

will cause the under-estimation to be 24%.Optimize transducer position to align the beam with the flow direction.

Screen pixel resolution

The display screen is composed of an array of square picture elements (pixels). The smallest resolvable unit is +/- 1pixel. This pixel error is only significant when measuring short distances on the screen. By observing good scanning practices, the settings of the field of view should be such that the measured distance covers a relatively large portion of the screen. When such scaling is impossible, the pixel error may come into play. The pixel error is +/- 0.2% of the full ultrasound area in the User Screen.

Algorithms

Some formulae used in clinical calculations are based on assumptions or approximations. For example the volume calculations from 2D or M mode assume a certain, ‘ideal’ shape of the heart chamber, while the actual shape can vary quite much between individuals. Also, formulae taking several “raw” measurements as inputs are prone to increased errors, depending on the combination of input variable accuracies. For example, the Cardiac Output formula from Doppler is sensitive to errors in the entered Diameter, since this will be squared in the formula.

Speed of Sound in Tissue

The average value 1540 meters / second is used for all calculations. Depending on the tissue structures, this generalization may give errors from 2% (typical) to 5% (much fatty tissue layers present).

Optimizing Measurement Accuracy

Probe selection

Select a transducer appropriate for the application, and optimize the transducer frequencies used. Higher imaging frequencies give better resolution, but less penetration than lower frequencies. Lower Doppler frequencies can measure higher max velocities, and at greater depths, but with less velocity resolution than higher Doppler frequencies.

Field of View

All display modes should be adjusted so that the area of interest covers as large portion of the display as possible. Use **Depth**, **Angle**, **Zoom**, **Horizontal Sweep** and **Velocity** controls to optimize the different modes.

Cursor Placement

Avoid placement of the cursor near the array edges when using convex or linear probes.

All measurements are dependent on the accuracy of their “input” data. Consistency and precision in placing cursors and drawing traces correctly on the images are important.

Measurement Uncertainties

The accuracy percentages reported below are based on data taken with optimum control settings, using calibrated phantoms and test equipment. The table below only includes errors related to the system with probes.

The calibration was done for the basic measurable parameters: Distance, Time and Velocity.

Independent sources of uncertainty contribute to a total uncertainty by a RMS (Root Mean Square) combination of the sources. Refer to the discussions above regarding measurement accuracy and sources of error when reading the table below.

Measurement	Range	Accuracy	Comments
2D Calipers			
Distance	1 - 10 cm	7%	
	> 10 cm	5%	
M-mode Calipers			
Distance	1 - 10 cm	7%	
dt	0.5 - 1.5 s	0.5%	With optimal sweep speed setting
Spectrum Calipers			
Velocity	0.2 - 1.5 m/s	6%	
dt	0.5 - 1.5 s	0.5%	With optimal sweep speed setting

DICOM SR Measurements

DICOM Structured Reporting (SR) is a standardized format for medical results. Vivid *i* and EchoPAC PC supports the specialized form for Adult Echo Ultrasound (“Supplement 72") for M&A results.

“Supplement 72" does not support all M&A results from Vivid *i* and EchoPAC PC. “Supplement 72" limits the information that is possible to send to the following:

- Publicly coded parameters (see table below), no pediatric or fetal cardiac and no unassigned measurements.
- Basic modes: 2D, M-mode, Color Flow, PW and CW Doppler.
- Publicly coded methods (see table), no Modified Simpson or Bullet methods.
- Basic derivations (Average and Last); no references between derived measurements and the ones they were made from.
- Wall Motion Scoring: individual segment scores only according to 16-segment model; no graded Hypokinesis (only Hypokinesis is used).

Supported parameters

Left ventricle

2D/%FS	CO(A-L A4C)/AutoHR	LVLs(apical)
2D/%IVS Thck	CO(A-L LAX)	LVOT CI
2D/%LVPW Thck	CO(A-L LAX)/AutoHR	LVOT CO
2D/CI(Cube)	CO(A-L)	LVOT HR
2D/CI(Teich)	CO(Biplane)	LVOT maxPG
2D/CO(Cube)	CO(Biplane)_03	LVOT meanPG
2D/CO(Teich)	CO(bp el)	LVOT SI
2D/EDV(A-L)	CO(bullet)	LVOT SV
2D/EDV(Cube)	CO(MOD A2C)	LVOT Vmax
2D/EDV(MOD)	CO(MOD A2C)/AutoHR	LVOT Vmax P

2D/EDV(Teich)	CO(MOD A4C)	LVOT Vmean
2D/EF(A-L)	CO(MOD A4C)/AutoHR	LVOT VTI
2D/EF(Cube)	CO(MOD LAX)	LVs Mass(A-L)
2D/EF(MOD)	CO(MOD LAX)/AutoHR	MM/%FS
2D/EF(Teich)	CO(mod sim)	MM/%LVPW Thck
2D/ESV(A-L)	EDV(bp el)	MM/CI(Cube)
2D/ESV(Cube)	EDV(bullet)	MM/CI(Teich)
2D/ESV(MOD)	EDV(mod sim)	MM/CO(Cube)
2D/ESV(Teich)	EF(A-L A2C)	MM/CO(Teich)
2D/IVSd	EF(A-L A4C)	MM/EDV(Cube)
2D/IVSs	EF(A-L LAX)	MM/EDV(Teich)
2D/LVA diastole	EF(Biplane)	MM/EF(Cube)
2D/LVA systole	EF(Biplane)_03	MM/EF(Teich)
2D/LVd Mass	EF(bp el)	MM/ESV(Cube)
2D/LVd Mass/ASE	EF(bullet)	MM/ESV(Teich)
2D/LVIDd	EF(MOD A2C)	MM/IVSd
2D/LVIDs	EF(MOD A4C)	MM/IVSd/LVPWd
2D/LVOT Area	EF(MOD LAX)	MM/IVSs
2D/LVOT Diam	EF(mod sim)	MM/LVd Mass
2D/LVPWd	ESV(bp el)	MM/LVd Mass/ASE
2D/LVPWs	ESV(bullet)	MM/LVIDd
2D/LVs Mass	ESV(mod sim)	MM/LVIDs
2D/LVs Mass/ASE	IVCT	MM/LVPWd
2D/SAX/LVA diastole	IVRT	MM/LVPWs
2D/SAX/LVA systole	LIMP	MM/LVs Mass
2D/SI(A-L)	LVAd(A2C)	MM/LVs Mass/ASE

2D/SI(Cube)	LVAd(A4C)	MM/SI(Cube)
2D/SI(MOD)	LVAd(LAX)	MM/SI(Teich)
2D/SI(Teich)	LVAd(sax MV)	MM/SV(Cube)
2D/SV(A-L)	LVAd(sax PM)	MM/SV(Teich)
2D/SV(Cube)	LVAd(sax)	MP/LVOT Diam
2D/SV(MOD)	LVAs(A2C)	MP/LVOT VTI
2D/SV(Teich)	LVAs(A4C)	SI(A-L A2C)
AP/LVOT Diam	LVAs(LAX)	SI(A-L A4C)
AP/LVOT VTI	LVAs(sax MV)	SI(A-L LAX)
CI(A-L A2C)	LVAs(sax PM)	SI(Biplane)
CI(A-L A2C)/AutoHR	LVAs(sax)	SI(Biplane)_03
CI(A-L A4C)	LVd Mass(A-L)	SI(bp el)
CI(A-L A4C)/AutoHR	LVEDV(A-L A2C)	SI(bullet)
CI(A-L LAX)	LVEDV(A-L A4C)	SI(MOD A2C)
CI(A-L LAX)/AutoHR	LVEDV(A-L LAX)	SI(MOD A4C)
CI(Biplane)	LVEDV(MOD A2C)	SI(MOD LAX)
CI(Biplane)_03	LVEDV(MOD A4C)	SI(mod sim)
CI(bp el)	LVEDV(MOD BP)	SV(A-L A2C)
CI(bullet)	LVEDV(MOD BP)_03	SV(A-L A4C)
CI(MOD A2C)	LVEDV(MOD LAX)	SV(A-L LAX)
CI(MOD A2C)/AutoHR	LVESV(A-L A2C)	SV(Biplane)
CI(MOD A4C)	LVESV(A-L A4C)	SV(Biplane)_03
CI(MOD A4C)/AutoHR	LVESV(A-L LAX)	SV(bp el)
CI(MOD LAX)	LVESV(MOD A2C)	SV(bullet)
CI(MOD LAX)/AutoHR	LVESV(MOD A4C)	SV(MOD A2C)
CI(mod sim)	LVESV(MOD BP)	SV(MOD A4C)

CO(A-L A2C)	LVESV(MOD BP)_03	SV(MOD LAX)
CO(A-L A2C)/AutoHR	LVESV(MOD LAX)	SV(mod sim)
CO(A-L A4C)	LVLd(apical)	

Right ventricle

2D/RVAWd	MM/RVAWs	RVOT meanPG
2D/RVAWs	MM/RVIDs	RVOT SI
2D/RVIDd	MM/RVOT	RVOT SV
2D/RVIDs	RIMP	RVOT Vmax
2D/RVOT Area	RVOT CI	RVOT Vmax P
2D/RVOT Diam	RVOT CO	RVOT Vmean
Est RVSP	RVOT HR	RVOT VTI
MM/RVAWd	RVOT maxPG	

Left atrium

2D/Ao/LA	LAESV(MOD A2C)	MM/LAAo/Ao/LA
2D/LA/Ao	LAESV(MOD A4C)	MM/LAAo/LA/Ao
LAESV(A-L A2C)	MM/Ao/LA	
LAESV(A-L A4C)	MM/LA/Ao	

Right atrium

RAAs(A4C)		
RAP		

Aortic valve

2D/AV Area	ARend maxPG	AVA (Vmax)

2D/AV Cusp	ARend Vmax	AVA (Vmax)2
2D/AV Diam	AV Acc Time	AVA (Vmax)P
2D/AVA Planimetry	AV Acc Time/ET Ratio	AVA (Vmax)P2
2D/AVA/AV Diam	AV CI	AVA (VTI)
2D/LAX/Trans AVA diastole	AV CO	AVET
2D/LAX/Trans AVA systole	AV Dec Slope	CFM/AR Signal Area
2D/SAX/Trans AVA diastole	AV Dec Time	MM/AV Cusp
2D/SAX/Trans AVA systole	AV HR	MM/AV Diam
AR Dec Slope	AV maxPG	PISA/AR/ERO
AR Dec Time	AV meanPG	PISA/AR/Flow
AR maxPG	AV SI	PISA/AR/RF
AR meanPG	AV SV	PISA/AR/RV
AR PHT	AV Vmax	PISA/AR/Vmax
AR Vmax	AV Vmax P	PISA/AR/VTI
AR Vmean	AV Vmean	
AR VTI	AV VTI	

Mitral valve

2D/MV Annulus Diam	MV A Dur	MV SI
2D/MV Area	MV A Velocity	MV SV
2D/MVA Planimetry	MV Acc Time	MV Vmax
2D/SAX/MVA	MV Acc Time/MV Dec Time	MV Vmean
CFM/MR Signal Area	MV CI	MV VTI

MCO	MV CO	MVA (PHT)
MM/EPSS	MV Dec Slope	MVA (VTI)
MM/MV E/A Ratio	MV Dec Time	PISA/MR/ERO
MM/MV E-F Slope	MV E Velocity	PISA/MR/Flow
MR dp/dt	MV E/A Ratio	PISA/MR/RF
MR maxPG	MV Eann Velocity	PISA/MR/RV
MR meanPG	MV HR	PISA/MR/Vmax
MR Vmax	MV maxPG	PISA/MR/VTI
MR Vmean	MV meanPG	
MR VTI	MV PHT	

Pulmonic valve

2D/PV Annulus Diam	PR maxPG	PV maxPG
2D/PV Area	PR meanPG	PV meanPG
CFM/PR Signal Area	PR PHT	PV Vmax
MM/Q-to-PV close	PR Vmax	PV Vmax P
PISA/PR/ERO	PR Vmean	PV Vmean
PISA/PR/Flow	PR VTI	PV VTI
PISA/PR/RV	PRend maxPG	PVA (Vmax)
PISA/PR/Vmax	PRend Vmax	PVA (Vmax)P
PISA/PR/VTI	PV Acc Time	PVA (VTI)
PR Dec Slope	PV Acc Time/ET Ratio	PVET
PR Dec Time	PV HR	SD/Q-to-PV close

Tricuspid valve

2D/TV Annulus Diam	TR meanPG	TV meanPG

2D/TV Area	TR Vmax	TV PHT
CFM/TR Signal Area	TR Vmean	TV Vmax
MM/Q-to-TV open	TR VTI	TV Vmax P
PISA/TR/ERO	TV A Velocity	TV Vmean
PISA/TR/Flow	TV Acc Time	TV VTI
PISA/TR/RV	TV Dec Slope	TVA
PISA/TR/Vmax	TV Dec Time	TVA (Vmax)
PISA/TR/VTI	TV E Velocity	TVA (Vmax)P
SD/Q-to-TV open	TV E/A Ratio	TVA (VTI)
TCO	TV HR	
TR maxPG	TV maxPG	

Aorta

MM/LAAo/Ao Root Diam	2D/Ao Desc Diam	2D/SAX/Trans AoD diastole
2D/Ao Root Diam	2D/Ao Isthmus	2D/SAX/Trans AoD systole
2D/Ao Asc Diam	2D/LAX/Trans AoD diastole	MM/Ao Root Diam
2D/Ao Arch Diam	2D/LAX/Trans AoD systole	

Pulmonary artery

2D/LPA	2D/RPA	
2D/MPA	MPA Vmax	

Pulmonary venous structure

P_Vein A	P_Vein D VTI	P_Vein S/D Ratio
P_Vein A Dur	P_Vein S	
P_Vein D	P_Vein S VTI	

Vena cava

2D/IVC		
2D/IVC Diam Exp		
2D/IVC Diam Ins		

Cardiac shunt study

Qp/Qs		

Congenital anomaly of cardiovascular system

2D/ASD Diam	ASD maxPG	VSD maxPG
2D/VSD Diam	ASD Vmax	VSD Vmax

Supported methods

Area-length, single plane
Method of Disks, single plane
Method of Disks, biplane
PISA
Teichholz
Cube
Left Ventricle Mass by M-mode

Planimetry
Biplane Ellipse
Pressure Half-Time
Continuity Equation by Velocity Time Integral
Continuity Equation by Peak Velocity

Chapter 1
Acoustic information

This chapter includes the following information:

The real-time display of acoustic output indices

The Vivid *i* has real-time display features according to Track 3 in the FDA 510(k) Guidance of 1997.It displays both a thermal (TI) and a mechanical (MI) index in all operating modes. These two indices are intended to estimate the potential for thermal and mechanical bioeffects induced by ultrasound. Both TI and MI are displayed with increments of 0.1. Neither are displayed if the value is below 0.4. The displayed (estimated) TI and MI are nominal values.

Thermal Index

TI is defined as:

$$TI = \frac{W_0}{W_{\text{deg}}}$$

where: W_0 is the time-averaged acoustic power and W_{deg} is the estimated power necessary to raise the target tissue one degree C.

The displayed TI is an estimate of temperature increase of soft tissue or bone, presented to make it easier for the operator to implement the ALARA (As Low As Reasonably Achievable) principle. There are three thermal index categories:

- **TIS**: Soft tissue thermal index. The main TI category. Used for applications that do not image bone.
- **TIB**: Bone thermal index (bone located in a focal region). Used for fetal application.
- **TIC**: Cranial bone thermal index (bone located close to the surface). Used for transcranial application.

The Vivid *i* chooses the correct category based on mode of operation and chosen application, and presents only one TI to the operator. It is therefore important that the operator chooses the right application.

Vivid *i* has an internal limit of 3.0 on TI. IEC87 has suggested some time dependent thresholds that are partly implemented on Vivid *i* as color-coding of the thermal index. The color-coding scheme together with the thermal exposure times in the

table below are not meant as limits on TI or exposure time, but as an aid for the operator. Note that Vivid *i* does not monitor the thermal exposure time. The displayed TI is coded like this:

TI	Color	Recommended thermal exposure time
0.0 – 0.4	Dimmed	-
0.4 – 1.5	White	-
1.5 – 2.0	White	< 12 h
2.0 – 3.0	White	< 1 h

Mechanical Index:

MI is the estimated likelihood of tissue damage due to cavitation. MI is defined as:

$$MI = \frac{p_{r.3}(z_{sp})}{\sqrt{f_c}}$$

where $p_{r.3}$ is the derated (attenuated) peak rarefactional (negative) pressure (MPa) and f_c is the center frequency (MHz).

The MI will not exceed a value of 1.9 according to Track 3 in the FDA 510(k) guidance of 1997.

Display Accuracy and Acoustic Measurement Uncertainties

The display accuracy and measurement precision of the output display are summarized in the table below.
Accuracy of the output display (TI, MI) parameters depends on the measurement system precision, the acoustic model used to calculate the parameters and variation in the acoustic output of probes and systems. The measurement precision and overall accuracy of the measurements have been assessed by determining both the random and the systematic uncertainties and given in percent at 95% confidence level.

Parameter	Estimated accuracy[a]	Measurement precision	
		M/Color/PW/CW	2D/CFM mode
Pressure, MI	± 25%	± 15%	
Power, TI	± 50%	± 30%	± 40%
Frequency	± 1%	± 1%	

a. Accuracy = (Measured value - displayed value)/displayed value * 100%

Track 3 ALARA Educational Program

The user should be familiar with the enclosed document “Medical Ultrasound Safety” (see page 145), published by AIUM (American Institute of Ultrasound in Medicine). This document is acceptable to FDA as meeting the content of the ALARA educational program. ALARA is an acronym for the principle of prudent use of diagnostic ultrasound by obtaining the diagnostic information at an output that is **A**s **L**ow **A**s **R**easonably **A**chievable.
In addition to the AIUM document, the sections “The real-time display of acoustic output indices” on page 2 and “Controls Affecting Acoustic Output” on page 5 should be studied carefully in order to implement ALARA.

Default Settings and Output Levels

The default acoustic output level will not exceed a thermal index (TI) of 3.0 or a mechanical index (MI) of 1.5.

The maximum default TI is 50% of the maximum possible TI (6.0) and the maximum default MI is 80% of the maximum possible MI (1.9).

The output level will not exceed the default level until the user intentionally increases the power level by adjusting the power control on the system.

The output level will return to default each time

- a new probe is chosen
- a new application is chosen
- a new patient is chosen.

Controls Affecting Acoustic Output

The initial means by which the user can affect acoustic output are by 1) selecting a probe, 2) selecting an application (exam category) and then 3) selecting the imaging mode or particular imaging characteristics. After these selections are made, the only user control that can affect the output is the acoustic output control. This is achieved through an acoustic output control scheme in which all parameters that directly or indirectly affect acoustic output are fed to the control algorithm. The

algorithm estimates all relevant parameters and compares them to the FDA limits.

Output levels remain below the limits with a 95% confidence margin. The absolute maximum allowable output for all applications is:

- ISPTA ≤ 720 mW/cm^2
- MI ≤ 1.9
- TI ≤ 6

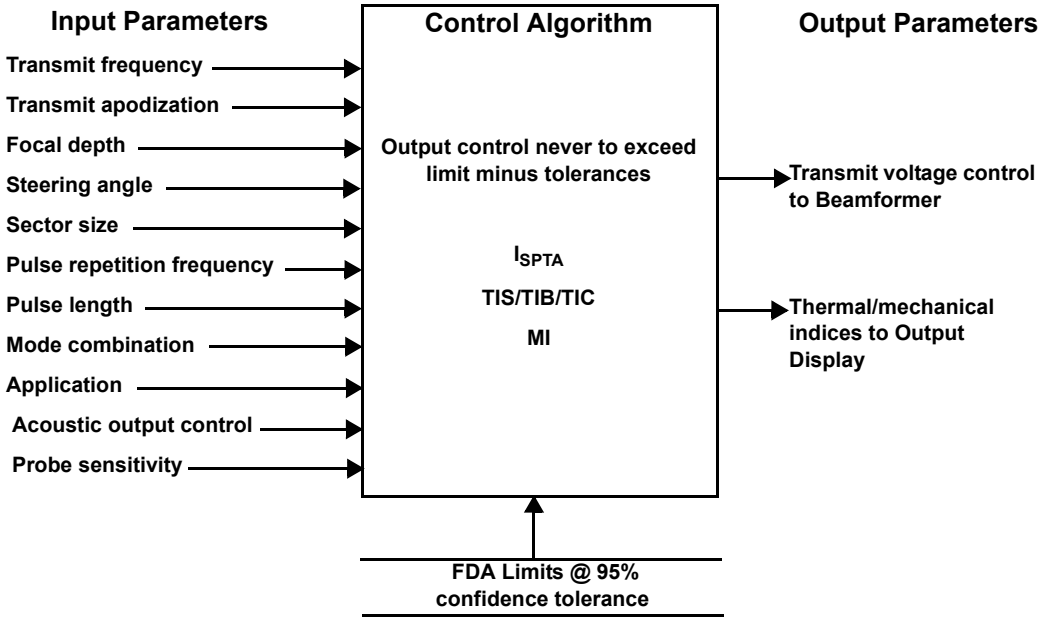

Figure 1-1 The Vivid *i* Acoustic Output Control Scheme

The following table summarizes the mode/probe combinations for which the global maximum displayed MI or TI may be greater than 1.0. For each probe/mode combination checked, a Track 3 acoustic output table exists.

Not all probes listed may be supported wordwide. Please refer to your local language User Manual for an overview of the probes that are supported in your country.

Track 3 Summary Table

Operating Mode	Transducer Model			
	3S-RS	7S-RS	10S-RS	3C-RS
B-Mode (2D)	Yes	Yes	Yes	Yes
M-Mode	Yes	Yes	Yes	Yes
Pulsed Doppler (PW)	Yes	Yes	Yes	Yes
CW Doppler (CW)	Yes	Yes	Yes	-
Color Flow (CFM)	Yes	Yes	Yes	Yes
Color M-Mode (CMM)	Yes	Yes	Yes	-

Operating Mode	Transducer Model			
	8L-RS	6T-RS	2D	6D
B-Mode (2D)	Yes	Yes	-	-
M-Mode	Yes	Yes	-	-
Pulsed Doppler (PW)	Yes	Yes	-	-
CW Doppler (CW)	-	Yes	Yes	Yes
Color Flow (CFM)	Yes	Yes	-	-
Color M-Mode (CMM)	-	Yes	-	-

Acoustic Parameters as Measured in Water

Definitions, symbols and abbreviations

The following definitions, symbols and abbreviations are used in the acoustic output reporting tables in this chapter:

FDA	IEC	Meaning—IEC 60601-2-37 / FDA & NEMA UD2, UD3
a	α	*Acoustic Attenuation Coefficient* / Derating factor (usually 0.3 dB/cm-MHz)
A_{aprt}	A_{aprt}	*-12db Output Beam Area* / Active aperture area
	C_{MI}	*Normalizing Coefficient*
D_{eq}	D_{eq}	*Equivalent Aperture Diameter* / (same)
d_{-6}	d_{-6}	*Pulse Beam Width* / Beam diameter at –6 dB
d_{eq}	d_{eq}	*Equivalent Beam Diameter*
f_c	f_{awf}	*Acoustic Working Frequency* / Center frequency
I_{pa}	I_{pa}	*Pulse-Average Intensity*
$I_{pa.3}$	$I_{pa,\alpha}$	*Attenuated Pulse-Average Intensity*
PII	I_{pi}	*Pulse-Intensity Integral*
$PII_{.3}$	$I_{pi,\alpha}$	*Attenuated Pulse-Intensity Integral*
I_{TA}	$I_{ta}(z)$	*Temporal-Average Intensity*
$I_{TA.3}(Z)$	$I_{ta,\alpha}(z)$	*Attenuated Temporal-Average Intensity* / (at depth z)
$I_{SPTA}(Z)$	$I_{zpta}(z)$	*Spatial-Peak Temporal-Average Intensity*
$I_{SPTA.3}(Z)$	$I_{zpta,\alpha}(z)$	*Attenuated Spatial-Peak Temporal-Average Intensity*
MI	*MI*	*Mechanical Index*
W_o	*P*	*Output Power* / Time average acoustic power at the source
$W_{.3}(Z)$	P_α	*Attenuated Output Power* / Time average acoustic power derated to depth z
W_{o1}	P_1	*Bounded Output Power* / Power emitted from the central 1cm of aperture
PII	p_i	*Pulse Pressure Squared Integral / Pulse intensity integral*
p_r	p_r	*Peak-Rarefactional Acoustic Pressure* / (same)
$p_{r.3}$	p_{ra}	*Attenuated Peak-Rarefactional Acoustic Pressure* / (same)
PRF	*prr*	*Pulse Repetition Rate* / Pulse repetition frequency

FDA	IEC	Meaning—IEC 60601-2-37 / FDA & NEMA UD2, UD3
TI	*TI*	*Thermal Index* / (same)
TIB	*TIB*	*Bone Thermal Index* / (same)
TIC	*TIC*	*Cranial-Bone Thermal Index* / (same)
TIS	*TIS*	*Soft-Tissue Thermal Index* / (same)
PD	t_d	*Pulse Duration* / (same)
x_{-12},y_{-12}	*X, Y*	*-12 dB Output Beam Dimensions* / (same)
Z	*z*	*Distance from the Source to a Specified Point* / (same)
Z_{sp}	z_b	*Depth for TIB* / Depth at which the relevant index is maximum
Z_{bp}	z_{bp}	*Break-Point Depth* / (same)
Z_{sp}	z_s	*Depth for TIS* / Depth at whcih the relevant index is maximum

符号	单位	定义
MI	不适用	机械指数
TIS_{scan}	不适用	自动扫描模式下的软组织热敏指数
$TIS_{non-scan}$	不适用	非自动扫描模式下的软组织热敏指数
TIB	不适用	骨组织热敏指数
TIC	不适用	头盖骨热敏指数
A_{aprt}	cm^2	有效孔径区
$P_{r.3}$	MPa	与可以产生 MI 报告值的传送模式关联的减额最大稀薄压 (MPa)
W_o	mW	超声功率，除了在使用 TIS_{scan} 的情况下，此时，它是指一厘米窗口内通过的超声功率
$W_{.3}(z_1)$	mW	减额超声功率 （轴长 z_1）
$I_{TA.3}(z_1)$	mW/cm^2	减额空间峰值、时间平均强度 （轴长 z_1）
z_1	cm	与 max [min($W_{.3}(z)$ ， $I_{TA.3}(z)$ x 1 cm^2)] 位置相对应的轴长，其中 $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	等效波束直径，轴长 z 的函数，等于 $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$，其中 $I_{TA}(z)$ 为时间平均强度，z 的函数
f_c	MHz	中心频率 对于 MI，f_c 为与可以产生 MI 最大报告值的传送模式关联的中心频率。 对于 TI，用于包括不同中心频率传送模式的组合模式时，f_c 定义为各个传送模式的所有中心频率
Dim. of A_{aprt}	cm	用于水平面和垂直平面的有效孔径
PD	μs	与可以产生 MI 报告值的传送模式关联的脉冲持续时间
PRF	Hz	与可以产生 MI 报告值的传送模式关联的脉冲重复频率
P_r @ PII_{max}	MPa	自由场、空间峰值脉冲强度积分最大处的峰值稀薄压
d_{eq} @ PII_{max}	cm	自由场、空间峰值脉冲强度积分最大处的等效波束直径
FL	cm	焦距，或者水平长度和垂直高度 （如果不同）
$I_{PA.3}$ @ MI_{max}	W/cm^2	MI 最大报告值处的减额脉冲平均强度
ROI	不适用	兴趣区
TB	不适用	轨迹球
CF	不适用	彩色模式
CM	不适用	彩色 M 模式
PW/CW	不适用	脉冲波 / 连续波多普勒

Symboler	Enhed	Definition
MI	n/a	Mekanisk indeks
TIS_{scan}	n/a	Termisk indeks for blødt væv i automatisk scanningsmode
$TIS_{non\text{-}scan}$	n/a	Termisk indeks over blødt væv i ikke-automatisk scanningsmode
TIB	n/a	Termisk indeks for knogler
TIC	n/a	Termisk indeks for kranieknogle
A_{aptr}	cm^2	Område af den aktive blænde
$P_{r.3}$	MPa	Belastningsreduceret, fortyndet maksimumtryk (MPa), der er knyttet til det sendemønster, der giver værdien, som er angivet for **MI**
W_o	mW	Ultralydeffekt, undtagen for **TIS_{scan}** hvor ultralydeffekten passerer gennem et vindue på 1 cm
$W_{.3}(z_1)$	mW	Belastningsreduceret ultralydeffekt ved aksialafstand **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Belastningsreduceret, tidsmæssigt gennemsnitsintensitet med rumligt maksimum ved aksialafstand z_1
z_1	cm	Aksialafstanden svarer til placeringen af maks. [min. (**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2)], hvor $z \geq z_{bp}$
z_{bp}		$1.69(A_{blænde})^{1/2}$
$d_{eq}(z)$	cm	Tilsvarende stråle diameter som funktion af aksialafstanden z, og lig med $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, hvor $I_{TA}(z)$ er den tidsmæssige gennemsnitsintensitet som funktion af z
f_c	MHz	Centerfrekvens Vedr. **MI** er **f_c** centerfrekvensen, der er knyttet til det sendemønster, der giver den maksimalt rapporterede værdi af **MI**. Vedr. **TI** i kombinerede mode, der involverer sendemønstre med ulige centerfrekvens, defineres **f_c** som det overordnede område af centerfrekvenser for de pågældende sendemønstre
Dim. of A_{aptr}	cm	Mål for aktiv blænde for azimut- og elevationsplan
PD	µs	Pulsvarighed, der er knyttet til det sendemønster, der giver værdien, som er angivet for **MI**
PRF	Hz	Pulsvarighedsfrekvensen, der er knyttet til det sendemønster, der giver værdien, som er angivet for **MI**
P_r @ PII_{max}	MPa	Maksimalt fortyndet tryk ved det punkt, hvor det frie, rumlige maksimum for pulsintensitetsintegralet er størst

Symboler	Enhed	Definition
d_{eq} @ PII_{max}	cm	Tilsvarende strålediameter ved det punkt, hvor det frie, rumlige maksimum for pulsintensitetsintegralet er størst
FL	cm	Fokuslængde eller azimut- og elevationslængde, hvis de er forskellige
$I_{PA.3}$ @ MI_{max}	W/cm^2	Belastningsreduceret gennemsnitspulsintensitet ved det maksimalt rapporterede punkt **MI**
ROI	n/a	Interesseområde
TB	n/a	Trackball
CF	n/a	Farve-Flow-Mode
CM	n/a	Farve-M-Mode
PW/CW	n/a	Pulsed Wave/Continuous Wave Doppler

Symboles	Unité	Définition
MI	n/d	Indice mécanique
TIS $_{scan}$	n/d	Indice thermique pour les tissus mous en mode d'auto-examen
TIS $_{non-scan}$	n/d	Indice thermique pour les tissus mous en mode de non-auto-examen
TIB	n/d	Indice thermique pour les os
TIC	n/d	Indice thermique crânien
A_{aprt}	cm^2	Zone d'ouverture active
$P_{r.3}$	MPa	Tensions rares de pic non notées (MPa) associées au schéma de transmission et donnant lieu à la valeur indiquée sous **MI**
W_o	mW	Puissance échographique, sauf pour l'examen **ITS $_{acq}$**, auquel cas il s'agit de la puissance échographique passant par une fenêtre d'un cm.
$W_{.3}(z_1)$	mW	Puissance échographique non cotée à distance axiale **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Pic spatial non coté, intensité temporelle moyenne à distance axiale z_1
z_1	cm	Distance axiale correspondant à l'emplacement du max [min(**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2)], où $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Diamètre de faisceau équivalent comme fonction de la distance axiale z, et égal à $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, où $I_{TA}(z)$ est l'intensité moyenne temporelle fonction de z
f_c	MHz	Fréquence centrale Pour **MI**, **f_c** est la fréquence centrale associée au schéma de transmission qui donne lieu à la valeur rapportée maximale de **MI**. Pour **TI**, pour des modes combinés impliquant des schémas de transmission de fréquence centrale inégale, **f_c** est défini comme la gamme totale des fréquences centrales des schémas de transmission respectifs
Dim. of A $_{aprt}$	cm	Dimensions d'ouverture active pour les plans azimutaux et d'élévation
PD	µs	Durée de pulsation associée au schéma de transmission donnant lieu à la valeur rapportée de **MI**
PRF	Hz	Fréquence de répétition associée au schéma de transmission donnant lieu à la valeur rapportée de **MI**
P_r @ PII_{max}	MPa	Tension de pic rare au point maximal de champ libre, d'intégrale d'intensité de pic spatial

Symboles	Unité	Définition
d_{eq} @ PII_{max}	cm	Diamètre de faisceau équivalent au point maximal de champ libre, d'intégrale d'intensité de pic spatial
FL	cm	Longueur focale ou longueurs azimutales et d'élévation, si elles sont différentes
$I_{PA.3}$ @ MI_{max}	W/cm^2	Intensité moyenne de pulsation non cotée au point maximum reporté **MI**
ROI	n/d	Région d'intérêt
TB	n/d	Trackball
CF	n/d	Mode de flux de couleurs
CM	n/d	Mode M Couleur
PW/CW	n/d	Doppler à ondes pulsées/continues

Symbole	Einheit	Bedeutung
MI	nicht zutreffend	Mechanischer Index
TIS_{scan}	nicht zutreffend	Soft Tissue Thermal Index im Auto-Scanning-Modus
$TIS_{non-scan}$	nicht zutreffend	Soft Tissue Thermal Index im Nicht-Auto-Scanning-Modus
TIB	nicht zutreffend	Bone Thermal Index
TIC	nicht zutreffend	Cranial Thermal Index
A_{aprt}	cm^2	Fläche der aktiven Apertur
$P_{r.3}$	MPa	Freigesetzter maximaler Verdünnungs-Druck (MPa) bei dem verwendeten Sendemuster, das zu dem unter **MI** angegebenen Wert führt
W_o	mW	Ultraschallleistung, außer beim **TIS_{scan}** , bei dem es sich um die Ultraschallleistung durch ein Ein-Zentimeter-Fenster handelt
$W_{.3}(z_1)$	mW	Freigesetzte Ultraschallleistung bei Axialabstand **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Freigesetzter räumlicher Spitzen- und zeitlicher Mittelwert der Intensität im Axialabstand z_1
z_1	cm	Axialabstand entsprechend der Position von max. [min.(**$W_{.3}(z)$** , **$I_{TA.3}(z)$** x 1 cm^2)], wobei $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Äquivalenter Strahldurchmesser als Funktion des Axialabstands z und gleich $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, wobei $I_{TA}(z)$ die zeitlich gemittelte Intensität als Funktion von z ist.
f_c	MHz	Mittenfrequenz Für **MI** ist **f_c** die Mittenfrequenz bei dem Sendemuster, das zum Maximalwert von **MI** führt. Für **TI** bei kombinierten Betriebsarten mit Sendemustern von ungleicher Mittenfrequenz ist **f_c** definiert als der Gesamtbereich der Mittenfrequenzen der jeweiligen Sendemuster
Dim. of A_{aprt}	cm	Maße der aktiven Apertur für die Azimutal- und die Elevationsebene
PD	µs	Pulsdauer des Sendemusters, das zum angegebenen Wert von **MI** führt
PRF	Hz	Pulswiederholungsfrequenz des Sendemusters, das zum angegebenen Wert von **MI** führt

Symbole	Einheit	Bedeutung
P_r @ $PII_{max.}$	MPa	Maximaler Verdünnungs-Druck an dem Punkt, an dem der räumliche Spitzenwert des Pulsintensitätsintegrals im freien Feld ein Maximum ist
d_{eq} @ $PII_{max.}$	cm	Äquivalenter Strahldurchmesser an dem Punkt, an dem der räumliche Spitzenwert des Pulsintensitätsintegrals im freien Feld ein Maximum ist
FL	cm	Fokuslänge bzw. Azimutal- und Elevationslänge, falls unterschiedlich
$I_{PA.3}$ @ $MI_{max.}$	W/cm^2	Reduzierter Pulsmittelwert der Intensität am Punkt des maximalen angegebenen **MI**
ROI	nicht zutreffend	Einstellbare Ausschnittsgröße
TB	nicht zutreffend	Trackball
CF	nicht zutreffend	Farbfluss-Modus
CM	nicht zutreffend	Farb-M-Modus
PW/CW	nicht zutreffend	Pulsed-Wave-/Continuous-Wave-Doppler

Simboli	Unità	Definizione
MI	n/a	Indice Meccanico
TIS_{scan}	n/a	Indice termico tessuti molli in modalità di scansione automatica
$TIS_{non\text{-}scan}$	n/a	Indice termico tessuti molli in modalità di scansione non automatica
TIB	n/a	Indice termico delle ossa
TIC	n/a	Indice termico cranico
A_{aprt}	cm^2	Area dell'apertura attiva
$P_{r.3}$	MPa	Pressione di rarefazione di picco a prestazioni ridotte (MPa) associata allo schema di trasmissione che genera il valore riportato alla voce **MI**
W_o	mW	Potenza ultrasuoni, tranne per **$TIS_{scansione}$** nel qual caso corrisponde alla potenza degli ultrasuoni che passa attraverso una finestra di un centimetro
$W_{.3}(z_1)$	mW	Potenza ultrasuoni a prestazioni ridotte in corrispondenza della distanza assiale **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Intensità media temporale, picco spaziale a prestazioni ridotte in corrispondenza della distanza assiale z_1
z_1	cm	Distanza assiale corrispondente alla posizione di max [min(**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2)], dove $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Diametro raggio equivalente in funzione della distanza assiale z e pari a $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, dove $I_{TA}(z)$ è l'intensità media temporale in funzione di z
f_c	MHz	Frequenza della parte centrale Per **MI**, **f_c** è la frequenza della parte centrale associata allo schema di trasmissione che genera il valore massimo riportato di **MI** Per **TI**, per le modalità che comportano schemi di trasmissione con frequenza della parte centrale ineguale, **f_c** è definito come la gamma totale delle frequenze della parte centrale dei rispettivi schemi di trasmissione
Dim. of A_{aprt}	cm	Le dimensioni dell'apertura attiva per i piani azimutali e verticali
PD	µs	Durata degli impulsi associata allo schema di trasmissione che genera il valore riportato di **MI**
PRF	Hz	Frequenza di ripetizione degli impulsi associata allo schema di trasmissione che genera il valore riportato di **MI**

Simboli	Unità	Definizione
P_r @ PII_{max}	MPa	Pressione di rarefazione di picco in corrispondenza del punto in cui l'integrale dell'intensità degli impulsi di picco spaziale a campo libero è al massimo
d_{eq} @ PII_{max}	cm	Diametro del raggio equivalente in corrispondenza del punto in cui l'integrale dell'intensità degli impulsi di picco spaziale a campo libero è al massimo
FL	cm	Lunghezza focale o lunghezze azimutali e verticali, se diverse
$I_{PA.3}$ @ MI_{max}	W/cm^2	Intensità della media degli impulsi a prestazioni ridotte in corrispondenza del punto del valore massimo riportato **MI**
ROI	n/a	Regione di interesse
TB	n/a	Trackball
CF	n/a	Color Flow
CM	n/a	Color M-Mode
PW/CW	n/a	Doppler PW/CW

記 号	単 位	定 義
MI	n/a	機械的指数。
TIS_{scan}	n/a	軟組織熱的指数。自動スキャンモードで使用。
$TIS_{non\text{-}scan}$	n/a	軟組織 熱的指数。自動スキャンモード以外で使用。
TIB	n/a	軟骨熱的指数。
TIC	n/a	頭蓋熱的指数。
A_{aprt}	cm^2	アクティブアパーチャーの面積。
$P_{r.3}$	MPa	緩和ピーク疎密圧力（MPa）。計測値 **MI** を発生する透過パターンで使用。
W_o	mW	超音波出力。**TIS_{scan}** では使用せず。TIS スキャンでは、1 センチメートルの窓を通過する超音波出力です。
$W_{.3}(z_1)$	mW	軸距離が **z_1** のときの緩和超音波出力。
$I_{TA.3}(z_1)$	mW/cm^2	緩和空間ピーク。軸距離が z_1 のときの時間平均密度。
z_1	cm	最大位置に対する軸距離 [min(**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2）] ここで、$z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	軸距離 z に換算した等価ビーム直径。$[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$ と同等。 ここで、$I_{TA}(z)$ は z に換算した時間平均密度。
f_c	（MHz）	中心周波数。 **MI** では、**f_c** は、最大計測値 **MI** を発生する透過パターンで使用する中心周波数。 **TI** の場合、不等中心周波数が発生する組み合わせモードでは、**f_c** は、各透過パターンの中心周波数の全範囲であると定義できます。
Dim. of A_{aprt}	cm	方位平面と高度平面におけるアクティブアパーチャーの規模。
PD	μs	パルス持続時間。計測値 **MI** を発生する透過パターンで使用。
PRF	Hz	パルス繰り返し周波数。計測値 **MI** を発生する透過パターンで使用。
P_r @ PII_{max}	MPa	フリーフィールド、空間 ピークパルス密度積分が最大のときのピーク希薄圧力。
d_{eq} @ PII_{max}	cm	フリーフィールド、空間 ピークパルス密度積分が最大になる地点での等価ビーム直径。
FL	cm	焦点距離、方位距離、または高度距離 （異なる場合）。
$I_{PA.3}$ @ MI_{max}	W/cm^2	最大計測値 **MI** を発生する地点における緩和パルス平均密度。

記 号	単 位	定 義
関心領域	n/a	関心領域
TB	n/a	トラックボール
CF	n/a	カラーフローモード
CM	n/a	カラー M モード
PW/CW	n/a	パルス波 / 連続波ドプラー

Símbolos	Unidad	Definición
MI	n/a	Índice Mecánico
TIS_{scan}	n/a	Índice Termal del Tejido Suave en el modo de auto-examinación
$TIS_{non-scan}$	n/a	Índice Termal del Tejido Suave en el modo de no-auto-examinación
TIB	n/a	Índice Termal del hueso
TIC	n/a	Índice Termal Craneal
A_{aprt}	cm^2	Área de la abertura activa
$P_{r.3}$	MPa	Presión rarefaccional máxima desratiza (MPa) asociada con el patrón transmitido aumentando el valor reportado bajo **MI**
W_O	mW	Potencia ultrasónica, con excepción para la **Examinación TIS** en la cual el caso es que la potencia ultrasónica pasando a través de una ventana de centímetro
$W_{.3}(z_1)$	mW	Potencia ultrasónica desratizada a una distancia axial **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Pico espacial desratizado, intensidad del promedio-temporal en la intensidad axial z_1
z_1	cm	Distancia axial correspondiente a la ubicación de máx [mín(**$W_{.3}(z)$** , **$ITA_{.3}(z)$** x 1 cm^2)], donde $z \geq zbp$
z_{bp}		$1.69(\mathbf{Aaprt})^{1/2}$
$d_{eq}(z)$	cm	Diámetro del haz equivalente como una función de distancia axial z, y es igual a $[(4/\pi)(W_0/ITA(z))]^{1/2}$, donde ITA(z) es la intensidad del promedio temporal como una función de z
fc	MHz	Centro de Frecuencia Para **MI**, **fc** es el centro de frecuencia asociado con el patrón de transmisión aumentando al máximo el valor reportado de **MI**. para **TI**, los modos combinados incluyendo los patrones transmitidos del centro de la frecuencia desigual, **fc** es definido como el rango general del centro de frecuencias de los patrones respectivos transmitidos
Dim. of A_{aprt}	cm	Dimensiones de abertura activa para los planos "azimuthal" y elevacionales
PD	µs	Duración del Pulso asociado con el patrón transmitido aumentando el valor reportado de **MI**
PRF	Hz	Frecuencia de reproducción del pulso asociado con el patrón transmitido aumentado en el valor reportado de **MI**
P_r @ PII_{max}	MPa	Presión rarefaccional máxima al punto del campo libre, intensidad integral pico del pulso espacial es un máximo

Símbolos	Unidad	Definición
d_{eq} @ PII_{max}	cm	El diámetro del haz equivalente al punto donde el campo libre, el pico espacial, intensidad integral del pulso es un máximo
FL	cm	Longitud focal o longitudes "azimutal" y elevacional, si es diferente
$I_{PA.3}$ @ MI_{max}	W/cm^2	La intensidad del promedio del pulso desratizado al punto máximo reportado de **MI**
ROI	n/a	Región de Interés
TB	n/a	"Trackball"
CF	n/a	Modo del Flujo de Color
CM	n/a	Modo de Color
PW/CW	n/a	Onda Pulsada/Onda Doppler Continua

Símbolos	Unidade	Definição
MI	n/d	Índice mecânico
TIS_{scan}	n/d	Índice térmico do tecido mole no modo de varredura automática
$TIS_{non-scan}$	n/d	Índice térmico do tecido mole no modo de varredura não automática
TIB	n/d	Índice térmico do osso
TIC	n/d	Índice térmico craniano
A_{aprt}	cm^2	Área da abertura ativa
$P_{r.3}$	MPa	Pressão de rarefação de pico reduzido (MPa) associada com a elevação fornecida do padrão de transmissão para o valor relatado sob **MI**
W_o	mW	A energia ultra-sônica, exceto por **$TIS_{varr.}$** no qual a energia ultra-sônica passa por uma janela de um centímetro
$W_{.3}(z_1)$	mW	Energia ultra-sônica reduzida na distância axial **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Pico espacial reduzido, intensidade média temporal na distância axial z_1
z_1	cm	Distância axial correspondente ao local de máx [mín(**$W_{.3}(z)$** , **$I_{TA.3}(z)$** x 1 cm^2)], onde $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Diâmetro equivalente do feixe como uma função da distância axial z é igual a $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, onde $I_{TA}(z)$ é a intensidade média temporal como uma função de z
f_c	Mhz	Freqüência central Para **MI**, **f_c** é a freqüência central associada com a elevação fornecida do padrão de transmissão para o valor máximo relatado de **MI**. Para **TI**, para os modos combinados envolvendo padrões de transmissão de freqüência central desigual, **f_c** é definido como o intervalo total de freqüências centrais dos respectivos padrões de transmissão
Dim. of A_{aprt}	cm	Dimensões da abertura ativa para os planos azimutais e de elevação
PD	µs	Duração do pulso associado à elevação fornecida do padrão de transmissão para o valor relatado de **MI**
PRF	Hz	Freqüência de repetição do pulso associado à elevação fornecida do padrão de transmissão para o valor relatado de **MI**
P_r @ PII_{max}	MPa	Pressão de rarefação do pico no ponto onde o campo livre, o integral de pulso do pico espacial é um máximo

Símbolos	Unidade	Definição
d_{eq} @ PII_{max}	cm	Diâmetro de feixe equivalente no ponto onde o campo livre, o integral de pulso do pico espacial é um máximo
CF	cm	Comprimento focal ou comprimentos de azimute e elevação, se forem diferentes
$I_{PA.3}$ @ MI_{max}	W/cm^2	Intensidade média do pulso reduzida no ponto do **MI** máximo relatado
ROI	n/d	Região de interesse
TB	n/d	Trackball
CF	n/d	Modo de fluxo colorido
CM	n/d	Modo M colorido
PW/CW	n/d	Doppler de onda pulsada/onda contínua

Symboler	Enhet	Definition
MI	n/a	Mekaniskt index
TIS_{scan}	n/a	Termiskt index för mjuk vävnad i automatiskt skanningsmode
$TIS_{non-scan}$	n/a	Termiskt index för mjuk vävnad i icke-automatiskt skanningsmode
TIB	n/a	Termiskt index för benvävnad
TIC	n/a	Termiskt index för kranialt
A_{aprt}	cm^2	Område för aktiv bländare
$P_{r.3}$	MPa	Undervärderat topptryck (MPa) associerat med rörelsemönstret som resulterar i värdet som rapporteras under **MI**
W_o	mW	Ultraljudskraft med undantag för **$TIS_{-skanning}$** då i vilket fall ultraljudskraften passerar genom ett en centimeter tjock fönster
$W_{.3}(z_1)$	mW	Undervärderad ultraljudskraft vid axiell distans **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Undervärderad spatial topp, temporal genomsnittsinentsitet via axiell diskans z_1
z_1	cm	Axiell distans korresponderande mot lokaliseringen av max [min(**$W_{.3}(z)$** , **$I_{TA.3}(z)$** x 1 cm^2)], där $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Ekvivalent stråldiameter som en funktion av axiell distans z och är lika med $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, där $_{TA}(z)$ är den temporala genomsnittsintensiteten com en funktion av z
f_c	MHz	Centrumfrekvens För **MI**, **f_c** är centrumfrekvensen associerad med överföringsmönstret som ger upphov till det maximala rapportvärdet av **MI**. För **TI**, för kombinderade inställningar (mode) som involverar överföringsmönster av olika centrumfrekvens **f_c** sär definierad som genomsnittsintervallet av centrumfrekvenser av respektive överförelsemönster
Dim. of A_{aprt}	cm	Aktiva bländardimensioner för azimutal- och lutande plan
PD	µs	Pulstryck associerat med överförelsemönstret som ger upphov till det rapporterade värdet i **MI**
PRF	Hz	Pulsrepetitionsfrekvens associerat med överförelsemönstret som ger upphov till det rapporterade värdet i **MI**
P_r @ PII_{max}	MPa	Ovanligt topptryck när frifältet, spatiala toppvärdet för pulsintensitetens integral är på max
d_{eq} @ PII_{max}	cm	Ekvivalent stråldiameter när frifältet, spatiala toppvärdet för pulsintensitetens integral är på max

Symboler	Enhet	Definition
FL	cm	Fokal längd eller azimutal- och lutande längder är olika
$I_{PA.3}$ @ MI_{max}	W/cm^2	Undervärderad pulsgenomsnittsintensitet vid maximalt rapporterad **MI**
ROI	n/a	Studerat område
TB	n/a	Styrkula
CF	n/a	Färgflödesläge
CM	n/a	Färg-M-mode
PW/CW	n/a	Pulsed Wave (PW-)/Continuous Wave (CW)-doppler

Symboler	Enhet	Definisjon
MI	n/a	Mekanisk Indeks
TIS_{scan}	n/a	Bløtdel Thermal Index i auto-skanning modus
$TIS_{non\text{-}scan}$	n/a	Bløtdel Thermal Index i non-auto-skanning modus
TIB	n/a	Bone Thermal Index
TIC	n/a	Kraniell Thermal Index
A_{aprt}	cm^2	Område for den aktive åpningen
$P_{r.3}$	MPa	Redusert maksimalt trykk (MPa) assosiert med sendemønsteret som gir grunnlag for verdien som angis under **MI**
W_o	mW	Ultralydeffekt, bortsett fra **TIS_{scan}** hvor det er ultralydeffekten som passerer gjennom et 1 centimeter vindu.
$W_{.3}(z_1)$	mW	Redusert ultralydeffekt i aksial avstand **z_1**
$I_{TA.3}(z_1)$	mW/ cm^2	Redusert romlig-peak, temporal-gjennomsnitt intensitet ved aksial avstand z_1
z_1	cm	Aksial distanse svarende til plasseringen av maks [min(**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2)], hvor $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Ekvivalent strålediameter som en funksjon av aksial distanse z, er lik $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, hvor $I_{TA}(z)$ er den temporale-gjennomsnitt intensiteten som en funksjon av z
f_c	MHz	Senterfrekvensen for **MI**, **f_c** er senterfrekvensen som er forbundet med sendemønsteret som er bakgrunnen for den maksimale rapporterte verdien av **MI**. For **TI**, for kombinerte moduser som involverer sendemønstre av ulik senterfrekvens, **f_c** er definert som det samlede området av senterfrekvenser for de respektive sendemønstrene
Dim. of A_{aprt}	cm	Aktive apertur dimensjoner for de azimuthale og opphevede planene
PD	µs	Pulsvarighet assosiert med sendemønsteret gir grunnlag for den rapporterte verdien av **MI**
PRF	Hz	Puls repetisjonsfrekvens assosiert med sendemønsteret som gir grunnlag for den rapporterte verdien av **MI**
P_r @ PII_{max}	MPa	Peak trykket ved det punkt hvor, romlig-peak pulsintensitet integralet er ved maksimum

d_{eq} @ PII_{max}	cm	Ekvivalent strålediameter ved det punktet hvor romlig-peak pulsintensitet integralet er ved maksimum
FL	cm	Fokal lengde, eller azimutale og høydelengder, er forskjellige
$I_{PA.3}$ @ MI_{max}	W/cm^2	Redusert puls gjennomsnitt intensitet ved punktet for maksimum **MI**
ROI	n/a	Interesseområde
TB	n/a	Trackball
CF	n/a	Fargedoppler modus
CM	n/a	Farge M Mode
PW/CW	n/a	Pulset/Kontinuerlig Doppler

Symbolit	Laite	Kuvaus
MI	e/k	Mekaaninen indeksi
TIS_{scan}	e/k	Kudoksen lämpöindeksi automaattisessa skannaustilassa
$TIS_{non-scan}$	e/k	Kudoksen lämpöindeksi manuaalisessa skannaustilassa
TIB	e/k	Luun lämpöindeksi
TIC	e/k	Kalloluun lämpöindeksi
A_{aprt}	cm^2	Aktiivisen apertuurin alue
$P_{r.3}$	MPa	Alennettu huippuvaimenemisen paine (MPa), joka liittyy siirtotapaan ja nostaa kohdassa **MI** ilmoitettua arvoa.
W_o	mW	Ultraääniteho, lukuun ottamatta **TIS_{scan}**, jolloin se on yhden senttimetrin levyisen ikkunan kautta kulkeva ultraääniteho.
$W_{.3}(z_1)$	mW	Alennettu ultraääniteho aksiaalisella etäisyydellä **z_1**
$I_{TA.3}(z_1)$	mW/cm^2	Alennettu spatiaalihuippu, väliaikainen tiheyskeskiarvo aksiaalisella etäisyydellä z_1
z_1	cm	Maksimin sijaintia vastaava aksiaalinen etäisyys [minimi (**$W_{.3}(z)$**, **$I_{TA.3}(z)$** x 1 cm^2)], jossa $z \geq z_{bp}$
z_{bp}		$1.69(A_{aprt})^{1/2}$
$d_{eq}(z)$	cm	Vastaava säteen halkaisija aksiaalisen etäisyyden z toimintona, joka vastaa $[(4/\pi)(W_0/I_{TA}(z))]^{1/2}$, jossa $I_{TA}(z)$ on z:n toiminnon lämpökeskiarvon tiheys.
f_c	MHz	Keskustaajuus Kohdan **MI**, **f_c** keskustaajuus liittyy siirtotapaan ja nostaa kohdassa **MI** ilmoitettua maksimiarvoa. **TI** yhdistelmätiloille, jotka liittyvät erilaisten keskustaajuuksien siirtokuvioihin, **f_c** määritetään vastaavien keskuskuvioiden kokonaisalueena.
Dim. of A_{aprt}	cm	Aktiivisen apertuurin mitat atsimutaalisille ja kohotetuille tasoille.
PD	µs	Siirtokuvioon liittyvä pulssin kesto, joka nostaa kohdassa **MI** ilmoitettua arvoa.
PRF	Hz	Siirtokuvioon liittyvä pulssin toistotaajuus, joka nostaa kohdassa **MI** ilmoitettua arvoa.
P_r @ PII_{max}	MPa	Huippuohentumisen paine pisteessä, jossa vapaa-kenttä, spatiaalisen huippupulssin tiheyden integraali, on maksimiarvossa.
d_{eq} @ PII_{max}	cm	Vastaava säteen halkaisija pisteessä, jossa vapaa-kenttä, spatiaalisen huippupulssin tiheyden integraali, on maksimiarvossa.

FL	cm	Tarkennuspituus tai atsimutaalinen ja kohotettu pituus (jos arvot eroavat).
$I_{PA.3}$ @ MI_{max}	W/cm^2	Alennetun pulssikeskiarvon tiheys maksimipisteessä, joka ilmoitetaan kohdassa **MI**
ROI	e/k	Kiinnostusalueet
TB	e/k	Ohjauspallo
CF	e/k	Värivirtaustila
CM	e/k	Värillinen M-tila
PW/CW	e/k	Pulssi-/jatkuva doppler

Explanation of Footnotes

The mechanical and thermal indices may be replaced by one of the following footnotes because of the reasons listed:

a. Display of this index is not required for this operating mode.

b. This probe is not intended for transcranial or neonatal cephalic uses.

c. This formulation for TIS is less than that for an alternate formulation in this mode.

If so, the table entries are replaced by a "#", meaning: no data are provided for this operating condition since the maximum reported value is not reported for the reason listed.

If neither an index or a footnote is given, this means that the index is irrelevant for this transducer/mode combination.

Multiple focal-zones

When using multiple focal-zones on System FiVe, the time in one frame is divided between the different focal-zones. When measuring this, the MI is found as the maximum MI of all zones:

$$MI = \max_{all\ zones}(MI)$$

while the TI and W_0 is found as the time-weighted sum of all zones:

$$TI = \sum_{all\ zones} TI_{zone} \cdot t_{zone}$$

$$W_0 = \sum_{all\ zones} W_{0_{zone}} \cdot t_{zone}$$

t_{zone} is the time fraction used per zone in a frame.

Some of the parameters in the acoustic output report tables will have one value per zone. In this case, the range of the parameter values is reported. The number of zones and which zone has the greater MI is also given in the tables.

Operating Conditions

All table entries are with the operating conditions specified at the end of the table.

Acoustic Output Reporting Tables for Track 3

Not all probes listed may be supported worldwide. Please refer to your local language User Manual for an overview of the probes that are supported in your country.

Acoustic Output Reporting Tables for Track 3/IEC 60601-2-37

Not all probes listed may be supported wordwide. Please refer to your local language User Manual for an overview of the probes that are supported in your country.

Transducer Model: 3S-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9	(a)	-	-	-	1.0
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.2					
	P	W(0)	(mW)		#	-		-	35.8
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	6.0				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	1.8	#	-	-	-	1.8
	Dim of A_{prt}	X	(cm)		#	-	-	-	1.9
		Y	(cm)		#	-	-	-	1.3
Other Info	t_d	PD.	(ms)	0.8					
	prr	PRF	(Hz)	4292					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.7					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		-
		FL_y	(cm)		#	-	-		0.6
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	80					
Operator Control		Power	(dB)	0	#	-	-	-	0
		Range	(cm)	10	#	-	-	-	10
		2D Angle	(deg)	10.0	#	-	-	-	10

a. This index is not required for this operating mode

No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3S-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9	-	-	0.1	0.3	0.1
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.2					
	P	W(0)	(mW)		-	-		7.6	8.6
		LPP	(mW)				6.3		
	Z_s	Z(1)	(cm)				2.6		
	Z_{bp}	Z(bp)	(cm)				2.6		
	z_b	Z(sp)	(cm)	5.0				4.5	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	$d_{eq}(Z_b)$	$d_{eq}(Z_{sp})$	(cm)					0.34	
	f_{awf}	f(c)	(MHz)	1.8	-	-	1.8	1.8	1.8
	Dim of A_{prt}	X	(cm)		-	-	1.9	1.9	1.9
		Y	(cm)		-	-	1.3	1.3	1.3
Other Info	t_d	PD.	(ms)	0.9					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	1.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.33	
	Focal Length	FL_x	(cm)		-	-	5.0		5.0
		FL_y	(cm)		-	-	6.0		6.0
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	64					
Operator Control		Power	(dB)	0	-	-	0	0	0
		Range	(cm)	10.0	-	-	10.0	10.0	10.0

Transducer Model: 3S-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0	0.5	-	-	-	0.9
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.3					
	P	W(0)	(mW)		63.3	-		-	34.0
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	4.0				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	1.8	1.8	-	-	-	1.8
	Dim of A_{prt}	X	(cm)		1.9	-	-	-	1.9
		Y	(cm)		1.3	-	-	-	1.3
Other Info	t_d	PD.	(ms)	2.0					
	prr	PRF	(Hz)	10000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.8					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		5.0	5.0	-		-
		FL_y	(cm)		6.0	-	-		6.0
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	80					
Operator Control		Power	(dB)	0	0	-	-	-	0
		Range	(cm)	10.0	10.0	-	-	-	10.0
		ROI depth	(cm)	5.0	5.0	-	-	-	5
		Velocity	(m/sec)	-	-	-	-	-	-
		ROI length	(mm)	20	20	-	-	-	2
		ROI width	(mm)	Min.	Min.	-	-	-	Min.
		2D Angle	(deg)	10	10	-	-	-	10

Transducer Model: 3S-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.7	-	-	0.3	1.4	0.7
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.0					
	P	W(0)	(mW)		-	-		47.7	47.7
		LPP	(mW)				176.5		
	Z_s	Z(1)	(cm)				2.6		
	Z_{bp}	Z(bp)	(cm)				2.6		
	z_b	Z(sp)	(cm)	5.0				4.5	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.39	
	f_{awf}	f(c)	(MHz)	1.8	-	-	1.8	1.8	1.8
	Dim of A_{prt}	X	(cm)		-	-	1.9	1.9	1.9
		Y	(cm)		-	-	1.3	1.3	1.3
Other Info	t_d	PD.	(ms)	0.9					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.45	
	Focal Length	FL_x	(cm)		-	-	5.0		5.0
		FL_y	(cm)		-	-	6.0		6.0
	$I_{pa.a}$@ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	64					
Operator Control		Power	(dB)	0	-	-	0	0	0
		Range	(cm)	10.0	-	-	14.0	10.0	10.0
		ROI depth	(cm)	5.0	-	-	5	5.0	5
		Velocity	(m/sec)	Min.	-	-	2.0	Max.	Max.
		ROI length	(mm)	20	-	-	-	20	2

Transducer Model: 3S-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9	-	-	0.6	2.2	1.5
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.3					
	P	W(0)	(mW)		-	-		94.0	94.0
		LPP	(mW)				70.4		
	Z_s	Z(1)	(cm)				2.3		
	Z_{bp}	Z(bp)	(cm)				2.3		
	z_b	Z(sp)	(cm)	4.0				5.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.51	
	f_{awf}	f(c)	(MHz)	1.8	-	-	1.8	1.8	1.8
	Dim of A_{prt}	X	(cm)		-	-	1.5	1.5	1.5
		Y	(cm)		-	-	1.3	1.3	1.3
Other Info	t_d	PD.	(ms)	0.9					
	prr	PRF	(Hz)	1109					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.8					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.48	
	Focal Length	FL_x	(cm)		-	-	12.9		12.9
		FL_y	(cm)		-	-	6.0		6.0
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	104					
Operator Control		Power	(dB)	0	-	0	-	0	0
		Range	(cm)	10.0	-	10.0	-	10.0	10.0
		SV depth	(cm)	8.0	-	8.0	-	8.0	8
		Velocity	(m/sec)	Min.	-	Max.	-	Max.	Max.
		SV	(mm)	1	-	1	-	3	1

Transducer Model: 3S-RS

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.11	-	1.0	-	3.7	2.5
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.2					
	P	W(0)	(mW)		-	106.7		108.0	108.0
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	4.0				4.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	$d_{eq}(Z_b)$	$d_{eq}(Z_{sp})$	(cm)					0.39	
	f_{awf}	f(c)	(MHz)	2.0	-	2.0	-	2.0	2.0
	Dim of A_{prt}	X	(cm)		-	0.7	-	0.7	0.7
		Y	(cm)		-	1.3	-	1.3	1.3
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	0.2					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.39	
	Focal Length	FL_x	(cm)		-	0.0	-		30.0
		FL_y	(cm)		-	6.0	6.0		6.0
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	0.529					
Operator Control		Power	(dB)	0	-	0	-	0	0
		Range	(cm)	10.0	-	10.0	-	10.0	10.0
		SV depth	(cm)	-	-	-	-	-	-
		Velocity	(m/sec)	-	-	Max.	-	-	-

Transducer Model: 7S-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0	(a)	-	-	-	#
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.1					
	P	W(0)	(mW)		#	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.7				-	
	Z@$I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	4.6	#	-	-	-	#
	Dim of A_{prt}	X	(cm)		#	-	-	-	#
		Y	(cm)		#	-	-	-	#
Other Info	t_d	PD.	(ms)	0.5					
	prr	PRF	(Hz)	4620					
	p_r@I_{pi} max	P_r@ P||max	(MPa)	3.3					
	d_{eq}@I_{pi} max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		#
		FL_y	(cm)		#	-	-		#
	$I_{pa.a}$@ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	175					
Operator Control		Power	(dB)	0	#	-	-	-	#
		Range	(cm)	16	#	-	-	-	#
		Focus	(cm)	4					
		2D Angle	(deg)	65.0	#	-	-	-	#

a. This index is not required for this operating mode

No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 7S-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0		0.2	-	0.4	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.1					
	P	W(0)	(mW)		-	8.2		8.2	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.7				2.9	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.21	
	f_{awf}	f(c)	(MHz)	4.6	-	4.6	-	4.6	(a)
	Dim of A_{prt}	X	(cm)		-	0.9	-	0.9	(a)
		Y	(cm)		-	0.7	-	0.7	(a)
Other Info	t_d	PD.	(ms)	0.6					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.1					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.21	
	Focal Length	FL_x	(cm)		-	4.0	-		(a)
		FL_y	(cm)		-	3.0	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	151					
Operator Control		Power	(dB)	0	-	-	0	0	(a)
		Focus	(cm)	4.0			4.0	4.0	(a)
		Range	(cm)	16.0	-	-	16.0	16.0	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 7S-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	0.6	-	-	-	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.6					
	P	W(0)	(mW)		26.1	-		-	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	3.0				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	4.4	4.4	-	-	-	(a)
	Dim of A_{prt}	X	(cm)		0.9	-	-	-	(a)
		Y	(cm)		0.7	-	-	-	(a)
Other Info	t_d	PD.	(ms)	1.3					
	prr	PRF	(Hz)	11900					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.7					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		3.0	3.0	-		(a)
		FL_y	(cm)		3.0	-	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	122					
Operator Control		Power	(dB)	0	0	-	-	-	(a)
		Range	(cm)	5.0	5.0	-	-	-	(a)
		ROI depth	(cm)	4.0	4.0	-	-	-	(a)
		SV	(mm)	1.0	1.2				(a)
		Velocity	(m/sec)	Max.	Max.	-	-	-	(a)
		ROI length	(mm)	20	20	-	-	-	(a)
		ROI width	(mm)	20	20				(a)
		2D Focus	(cm)	4	4	-	-	-	
		2D Angle	(deg)	46	46	-	-	-	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 7S-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.6	-	0.2	-	0.5	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.3					
	P	W(0)	(mW)		-	10.2		10.2	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.7				2.5	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.21	
	f_{awf}	f(c)	(MHz)	4.6	-	4.4	-	4.4	(a)
	Dim of A_{prt}	X	(cm)		-	0.9	-	0.9	(a)
		Y	(cm)		-	0.7	-	0.7	(a)
Other Info	t_d	PD.	(ms)	0.6					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.1					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.16	
	Focal Length	FL_x	(cm)		-	3.0	-		(a)
		FL_y	(cm)		-	3.0	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	151					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		ROI depth	(cm)	4.0	-	4.0	-	4.0	(a)
		SV	(mm)	1.2	-	1.2		1.2	(a)
		Velocity	(m/sec)	Min.	-	Min.	-	Max.	(a)
		M Focus	(cm)	3.0		3.0	-	3.0	
		ROI length	(mm)	20	-	20	-	20	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 7S-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.1	-	0.4	-	1.6	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.9					
	P	W(0)	(mW)		-	30.4		30.4	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.7				2.5	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.25	
	f_{awf}	f(c)	(MHz)	3.2	-	3.0	-	3.0	(a)
	Dim of A_{prt}	X	(cm)		-	0.7	-	0.7	(a)
		Y	(cm)		-	0.7	-	0.7	(a)
Other Info	t_d	PD.	(ms)	1.1					
	prr	PRF	(Hz)	1667					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	2.4					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.24	
	Focal Length	FL_x	(cm)		-	6.8	6.8		(a)
		FL_y	(cm)		-	3.0	3.0		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	169					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	8.0	-	8.0	-	8.0	(a)
		SV depth	(cm)	2.0	-	2.0	-	2.0	(a)
		Velocity	(m/sec)	0.4	-	1.9	-	1.9	(a)
		SV	(mm)	1	-	2	-	2	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 7S-RS

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.06	-	0.4	-	1.3	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.1					
	P	W(0)	(mW)		-	24.9		24.9	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	1.9				1.8	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.28	
	f_{awf}	f(c)	(MHz)	3.4	-	3.4	-	3.4	(a)
	Dim of A_{prt}	X	(cm)		-	0.4	-	0.4	(a)
		Y	(cm)		-	0.7	-	0.7	(a)
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	0.4					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.28	
	Focal Length	FL_x	(cm)		-	0.0	-		(a)
		FL_y	(cm)		-	3.0	3.0		(a)
	$I_{pa.a}$@ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	2					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		SV depth	(cm)	-	-	-	-	-	(a)
		Velocity	(m/sec)	Max.	-	Max.	-	Max.	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0	(a)	-	-	-	#
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.2					
	P	W(0)	(mW)		#	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	5.7	#	-	-	-	#
	Dim of A_{prt}	X	(cm)		#	-	-	-	#
		Y	(cm)		#	-	-	-	#
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	10131					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	3.3					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		#
		FL_y	(cm)		#	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	216					
Operator Control		Power	(dB)	0	#	-	-	-	#
		Range	(cm)	16	#	-	-	-	#
		Focus	(cm)	4					
		2D Angle	(deg)	65.0	#	-	-	-	#

a. This index is not required for this operating mode

No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9		0.1	-	0.3	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.2					
	P	W(0)	(mW)		-	3.7		3.7	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				2.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	$d_{eq}(Z_b)$	$d_{eq}(Z_{sp})$	(cm)					0.14	
	f_{awf}	f(c)	(MHz)	5.7	-	5.7	-	5.7	(a)
	Dim of A_{prt}	X	(cm)		-	0.6	-	0.6	(a)
		Y	(cm)		-	0.4	-	0.4	(a)
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	3.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.16	
	Focal Length	FL_x	(cm)		-	3.0	-		(a)
		FL_y	(cm)		-	2.0	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	177					
Operator Control		Power	(dB)	0	-	-	0	0	(a)
		Focus	(cm)	4.0			4.0	4.0	(a)
		Range	(cm)	16.0	-	-	16.0	16.0	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.7	0.2	-	-	-	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.7					
	P	W(0)	(mW)		7.9	-		-	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.2				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	5.7	5.7	-	-	-	(a)
	Dim of A_{prt}	X	(cm)		0.6	-	-	-	(a)
		Y	(cm)		0.4	-	-	-	(a)
Other Info	t_d	PD.	(ms)	1.0					
	prr	PRF	(Hz)	10000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		3.0	3.0	-		(a)
		FL_y	(cm)		2.2	-	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	147					
Operator Control		Power	(dB)	0	0	-	-	-	(a)
		Range	(cm)	5.0	5.0	-	-	-	(a)
		ROI depth	(cm)	4.0	4.0	-	-	-	(a)
		SV	(mm)	1.0	1.2	-	-	-	(a)
		Velocity	(m/sec)	Max.	Max.	-	-	-	(a)
		ROI length	(mm)	20	20	-	-	-	(a)
		ROI width	(mm)	20	20				(a)
		2D Focus	(cm)	4	4	-	-	-	
		2D Angle	(deg)	46	46	-	-	-	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0	-	0.2	-	0.4	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.2					
	P	W(0)	(mW)		-	7.7		7.7	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				2.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.17	
	f_{awf}	f(c)	(MHz)	5.7	-	5.4	-	5.4	(a)
	Dim of A_{prt}	X	(cm)		-	0.6	-	0.6	(a)
		Y	(cm)		-	0.4	-	0.4	(a)
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.14	
	Focal Length	FL_x	(cm)		-	3.0	-		(a)
		FL_y	(cm)		-	2.2	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	177					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		ROI depth	(cm)	4.0	-	4.0	-	4.0	(a)
		SV	(mm)	1.2	-	1.2		1.2	(a)
		Velocity	(m/sec)	Min.	-	Max.	-	Max.	(a)
		M Focus	(cm)	3.0		3.0	-	3.0	
		ROI length	(mm)	20	-	20	-	20	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.4	-	0.6	-	1.1	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.9					
	P	W(0)	(mW)		-	24.8		24.8	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.5				2.3	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.23	
	f_{awf}	f(c)	(MHz)	5.0	-	5.0	-	5.0	(a)
	Dim of A_{prt}	X	(cm)		-	0.6	-	0.6	(a)
		Y	(cm)		-	0.4	-	0.4	(a)
Other Info	t_d	PD.	(ms)	1.4					
	prr	PRF	(Hz)	5155					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.3					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.20	
	Focal Length	FL_x	(cm)		-	7.6	7.6		(a)
		FL_y	(cm)		-	2.2	2.2		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	40					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	8.0	-	8.0	-	8.0	(a)
		SV depth	(cm)	2.0	-	2.0	-	2.0	(a)
		Velocity	(m/sec)	0.4	-	1.9	-	1.9	(a)
		SV	(mm)	1	-	2	-	2	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 10S-RS

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.04	-	0.3	-	0.8	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.1					
	P	W(0)	(mW)		-	12.2		12.2	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	1.7				1.7	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.20	
	f_{awf}	f(c)	(MHz)	5.0	-	5.0	-	5.0	(a)
	Dim of A_{prt}	X	(cm)		-	0.3	-	0.3	(a)
		Y	(cm)		-	0.4	-	0.4	(a)
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	0.4					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.22	
	Focal Length	FL_x	(cm)		-	0.0	-		(a)
		FL_y	(cm)		-	2.2	2.2		(a)
	$I_{pa.a}$@ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	2					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		SV depth	(cm)	-	-	-	-	-	(a)
		Velocity	(m/sec)	Max.	-	Max.	-	Max.	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3C-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.0	(a)	-	-	-	(b)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.8					
	P	W(0)	(mW)		#	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	4.2				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	3.5	#	-	-	-	#
	Dim of A_{prt}	X	(cm)		#	-	-	-	#
		Y	(cm)		#	-	-	-	#
Other Info	t_d	PD.	(ms)	0.6					
	prr	PRF	(Hz)	7252					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		#
		FL_y	(cm)		#	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	113					
Operator Control		Power	(dB)	0	#	-	-	-	#
		Focus	(cm)	4.6	#	-	-	-	#
		Range	(cm)	8	#	-	-	-	#
		2D Angle	(deg)	30.0	#	-	-	-	#

a. This index is not required for this operating mode
b.This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3C-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				1.1		-	0.2	0.6	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	2.0					
	P	W(0)	(mW)		-	-		18.8	#
		LPP	(mW)				12.3		
	Z_s	Z(1)	(cm)				1.8		
	Z_{bp}	Z(bp)	(cm)				1.8		
	z_b	Z(sp)	(cm)	4.2				4.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.27	
	f_{awf}	f(c)	(MHz)	3.5	-	-	3.5	3.5	#
	Dim of A_{prt}	X	(cm)		-	-	1.1	1.1	#
		Y	(cm)		-	-	1.0	1.0	#
Other Info	t_d	PD.	(ms)	0.7					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.8					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					2.8	
	Focal Length	FL_x	(cm)		-	-	4.7		#
		FL_y	(cm)		-	-	5.0		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	166					
Operator Control		Power	(dB)	0	-	-	0	0	#
		Focus	(cm)	4.6			4.6	4.6	#
		Range	(cm)	20.0	-	-	20.0	20.0	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3C-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9	1.5	-	-	-	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.7					
	P	W(0)	(mW)		98.5	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	3.8				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	3.1	3.1	-	-	-	#
	Dim of A_{prt}	X	(cm)		1.6	-	-	-	#
		Y	(cm)		1.0	-	-	-	#
Other Info	t_d	PD.	(ms)	1.8					
	prr	PRF	(Hz)	9615					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		3.2	0.0	-		#
		FL_y	(cm)		5.0	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	126					
Operator Control		Power	(dB)	0	0	-	-	-	#
		Range	(cm)	8.0	8.0	-	-	-	#
		ROI start depth	(cm)	1.0	1.0	-	-	-	#
		Dopp. PRF	(KHz)	9.2	9.2	-	-	-	#
		ROI length	(mm)	45	45	-	-	-	#
		ROI width	(deg)	14	14	-	-	-	#
		2D Angle	(deg)	30	30	-	-	-	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3C-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.9	-	-	0.2	0.5	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.7					
	P	W(0)	(mW)		-	-		14.5	#
		LPP	(mW)				90.5		
	Z_s	Z(1)	(cm)				1.8		
	Z_{bp}	Z(bp)	(cm)				1.8		
	z_b	Z(sp)	(cm)	4.2				3.7	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.24	
	f_{awf}	f(c)	(MHz)	3.5	-	-	3.1	3.1	#
	Dim of A_{prt}	X	(cm)		-	-	1.6	1.6	#
		Y	(cm)		-	-	1.0	1.0	#
Other Info	t_d	PD.	(ms)	0.7					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.8					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.20	
	Focal Length	FL_x	(cm)		-	-	3.3		#
		FL_y	(cm)		-	-	5.0		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	166					
Operator Control		Power	(dB)	0	-	-	0	0	#
		Range	(cm)	8.0	-	-	8.0	8.0	#
		ROI depth	(cm)	3.3	-	-	3.3	3.3	#
		Velocity	(m/sec)	Max.	-	-	Max.	Max.	#
		ROI length	(mm)	45	-	-	45	45	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 3C-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	-	-	0.4	1.8	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.4					
	P	W(0)	(mW)		-	-		42.0	#
		LPP	(mW)				27.8		
	Z_s	Z(1)	(cm)				1.9		
	Z_{bp}	Z(bp)	(cm)				1.9		
	z_b	Z(sp)	(cm)	3.7				3.7	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.24	
	f_{awf}	f(c)	(MHz)	3.1	-	-	3.1	3.1	#
	Dim of A_{prt}	X	(cm)		-	-	1.3	1.3	#
		Y	(cm)		-	-	1.0	1.0	#
Other Info	t_d	PD.	(ms)	0.9					
	prr	PRF	(Hz)	2900					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.24	
	Focal Length	FL_x	(cm)		-	-	3.2		#
		FL_y	(cm)		-	-	5.0		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	97					
Operator Control		Power	(dB)	0	-	-	0	0	#
		Range	(cm)	8.0	-	-	8.0	8.0	#
		SV depth	(cm)	3.0	-	-	3.0	3.0	#
		Velocity	(m/sec)	0.6	-	-	3.4	3.4	#
		SV	(mm)	1	-	-	2	2	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 8L-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	(a)	-	-	-	(b)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.9					
	P	W(0)	(mW)		#	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.8				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	6.5	#	-	-	-	#
	Dim of A_{prt}	X	(cm)		#	-	-	-	#
		Y	(cm)		#	-	-	-	#
Other Info	t_d	PD.	(ms)	0.3					
	prr	PRF	(Hz)	15082					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		#
		FL_y	(cm)		#	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	168					
Operator Control		Power	(dB)	0	#	-	-	-	#
		Focus	(cm)	2.6	#	-	-	-	#
		Range	(cm)	3	#	-	-	-	#
		2D Angle	(deg)	27.0	#	-	-	-	#

a. This index is not required for this operating mode
b.This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 8L-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.7		0.1	-	0.1	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.8					
	P	W(0)	(mW)		-	2.4		2.4	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.6				2.4	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	$d_{eq}(Z_b)$	$d_{eq}(Z_{sp})$	(cm)					0.13	
	f_{awf}	f(c)	(MHz)	6.5	-	6.5	-	6.5	#
	Dim of A_{prt}	X	(cm)		-	0.9	-	0.9	#
		Y	(cm)		-	0.4	-	0.4	#
Other Info	t_d	PD.	(ms)	0.3					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	2.9					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.13	
	Focal Length	FL_x	(cm)		-	2.6	-		#
		FL_y	(cm)		-	2.6	2.6		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	130					
Operator Control		Power	(dB)	0	-	0	-	0	#
		Focus	(cm)	2.6		2.6		2.6	
		Range	(cm)	10.0	-	10.0	-	10.0	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 8L-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.7	0.5	-	-	-	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.8					
	P	W(0)	(mW)		20.1	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.5				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	4.5	4.5	-	-	-	#
	Dim of A_{prt}	X	(cm)		1.4	-	-	-	#
		Y	(cm)		0.4	-	-	-	#
Other Info	t_d	PD.	(ms)	1.4					
	prr	PRF	(Hz)	12000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	3.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		2.4	-	-		#
		FL_y	(cm)		2.6	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	140					
Operator Control		Power	(dB)	0	0	-	-	-	#
		Range	(cm)	4.0	4.0	-	-	-	#
	ROI start depth		(cm)	1.0	1.0	-	-	-	#
		Velocity	(m/sec)	-	-	-	-	-	#
		ROI length	(mm)	15	15	-	-	-	#
		ROI width	(deg)	7	7	-	-	-	#
		2D width	(mm)	27	27	-	-	-	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 8L-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.6	-	-	0.1	1.2	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.6					
	P	W(0)	(mW)		-	-		8.8	#
		LPP	(mW)				3.6		
	Z_s	Z(1)	(cm)				2.1		
	Z_{bp}	Z(bp)	(cm)				2.1		
	z_b	Z(sp)	(cm)	2.6				0.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.16	
	f_{awf}	f(c)	(MHz)	6.5	-	-	4.5	4.5	#
	Dim of A_{prt}	X	(cm)		-	-	1.5	1.5	#
		Y	(cm)		-	-	0.4	1.8	#
Other Info	t_d	PD.	(ms)	0.3					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.9					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.13	
	Focal Length	FL_x	(cm)		-	-	2.5		#
		FL_y	(cm)		-	-	2.6		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	1.30					
Operator Control		Power	(dB)	0	-	-	0	0	#
		Range	(cm)	4.0	-	-	4.0	4.0	#
		ROI depth	(cm)	2.5	-	-	2.5	2.5	#
		Velocity	(m/sec)	Max.	-	-	Max.	Max.	#
		ROI length	(mm)	20	-	-	20	20	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 8L-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.6	-	0.5	-	1.2	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.2					
	P	W(0)	(mW)		-	27.0		27.0	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	3.5				3.1	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.22	
	f_{awf}	f(c)	(MHz)	5.7	-	4.0	-	4.0	#
	Dim of A_{prt}	X	(cm)		-	1.0	-	1.0	#
		Y	(cm)		-	0.4	-	0.4	#
Other Info	t_d	PD.	(ms)	1.9					
	prr	PRF	(Hz)	1540					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	1.8					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.21	
	Focal Length	FL_x	(cm)		-	4.1	-		#
		FL_y	(cm)		-	2.6	2.6		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	69					
Operator Control		Power	(dB)	0	-	0	-	0	#
		Range	(cm)	4.0	-	4.0	-	4.0	#
		SV depth	(cm)	4.0	-	4.0	-	4.0	#
		Velocity	(m/sec)		-		-		#
		SV	(mm)	1.4	-	1.4	-	1.4	#

a. This probe is not intended for transcranial or neonatal cephalic use.
No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: 2D

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	(a)	-	-	-	#
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.7					
	P	W(0)	(mW)		#	-		-	#
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	4.8	#	-	-	-	#
	Dim of A_{prt}	X	(cm)		#	-	-	-	#
		Y	(cm)		#	-	-	-	#
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	7700					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	2.3					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		#	-	-		#
		FL_y	(cm)		#	-	-		#
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	122					
Operator Control		Power	(dB)	0	#	-	-	-	#
		Range	(cm)	12	#	-	-	-	#
		Focus	(cm)	5					
		2D Angle	(deg)	30.0	#	-	-	-	#

a. This index is not required for this operating mode

No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: M-Mode

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8		0.1	-	0.2	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.8					
	P	W(0)	(mW)		-	5.1		5.1	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				2.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.33	
	f_{awf}	f(c)	(MHz)	4.7	-	4.7	-	4.7	(a)
	Dim of A_{prt}	X	(cm)		-	0.8	-	0.8	(a)
		Y	(cm)		-	0.9	-	0.9	(a)
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.5					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.33	
	Focal Length	FL_x	(cm)		-	3.0	-		(a)
		FL_y	(cm)		-	4.5	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	111					
Operator Control		Power	(dB)	0	-	-	0	0	(a)
		Focus	(cm)	5.0			5.0	5.0	(a)
		Range	(cm)	12.0	-	-	12.0	12.0	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: CFM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.7	0.7	-	-	-	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.5					
	P	W(0)	(mW)		29.9	-		-	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.9				-	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					-	
	f_{awf}	f(c)	(MHz)	5.0	5.0	-	-	-	(a)
	Dim of A_{prt}	X	(cm)		0.9	-	-	-	(a)
		Y	(cm)		0.9	-	-	-	(a)
Other Info	t_d	PD.	(ms)	1.2					
	prr	PRF	(Hz)	11900					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.6					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					-	
	Focal Length	FL_x	(cm)		4.5	-	-		(a)
		FL_y	(cm)		4.5	-	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	78					
Operator Control		Power	(dB)	0	0	-	-	-	(a)
		Range	(cm)	12.0	12.0	-	-	-	(a)
		ROI depth	(cm)	5.0	5.0	-	-	-	(a)
		SV	(mm)	1	1	-	-	-	(a)
		Velocity	(m/sec)	1.2	1.2	-	-	-	(a)
		ROI length	(mm)	20	20	-	-	-	(a)
		ROI width	(mm)	15	15				(a)
		2D Focus	(cm)	5	5	-	-	-	(a)
		2D Angle	(deg)	30	30	-	-	-	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: CMM

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	-	0.5	-	0.7	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.7					
	P	W(0)	(mW)		-	24.2		24.2	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	2.0				2.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.30	
	f_{awf}	f(c)	(MHz)	4.7	-	4.4	-	4.4	(a)
	Dim of A_{prt}	X	(cm)		-	0.9	-	0.9	(a)
		Y	(cm)		-	0.9	-	0.9	(a)
Other Info	t_d	PD.	(ms)	0.4					
	prr	PRF	(Hz)	1000					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.5					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.23	
	Focal Length	FL_x	(cm)		-	0.6	-		(a)
		FL_y	(cm)		-	4.5	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	111					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	12.0	-	12.0	-	12.0	(a)
		ROI depth	(cm)	5.0	-	5.0	-	5.0	(a)
		SV	(mm)	1	-	1	-	1	(a)
		Velocity	(m/sec)	1.2	-	1.2	-	1.2	(a)
		M Focus	(cm)	3.0		3.0		3.0	(a)
		ROI length	(mm)	30	-	30	-	30	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: PW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.8	-	0.3	-	1.4	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	1.5					
	P	W(0)	(mW)		-	23.5		23.5	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	3.0				3.0	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.19	
	f_{awf}	f(c)	(MHz)	3.3	-	3.1	-	3.1	(a)
	Dim of A_{prt}	X	(cm)		-	0.9	-	0.9	(a)
		Y	(cm)		-	0.9	-	0.9	(a)
Other Info	t_d	PD.	(ms)	0.9					
	prr	PRF	(Hz)	1712					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	2.1					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.27	
	Focal Length	FL_x	(cm)		-	9.3	-		(a)
		FL_y	(cm)		-	4.5	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	138					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	12.0	-	12.0	-	12.0	(a)
		SV depth	(cm)	3.4	-	3.4	-	3.4	(a)
		Velocity	(m/sec)	0.4	-	1.2	-	1.2	(a)
		SV	(mm)	1	-	1	-	1	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6T-RS

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.04	-	0.2	-	0.8	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.1					
	P	W(0)	(mW)		-	14.7		14.7	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	1.5				1.3	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.30	
	f_{awf}	f(c)	(MHz)	3.3	-	3.3	-	3.3	(a)
	Dim of A_{prt}	X	(cm)		-	0.4	-	0.4	(a)
		Y	(cm)		-	0.9	-	0.9	(a)
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	0.1					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.29	
	Focal Length	FL_x	(cm)		-	0.0	-		(a)
		FL_y	(cm)		-	4.5	-		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	123					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	12.0	-	12.0	-	12.0	(a)
		SV depth	(cm)	-	-	-	-	-	(a)
		Velocity	(m/sec)	1.2	-	1.2	-	1.2	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 2D

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.09	-	0.5	-	2.7	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.1					
	P	W(0)	(mW)		-	53.2		53.2	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	1.1				1.1	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	$d_{eq}(Z_b)$	$d_{eq}(Z_{sp})$	(cm)					0.38	
	f_{awf}	f(c)	(MHz)	2.0	-	2.0	-	2.0	(a)
	Dim of A_{prt}	X	(cm)		-	0.7	-	0.7	(a)
		Y	(cm)		-	1.5	-	1.5	(a)
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	$P_r@$ P||max	(MPa)	0.1					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.38	
	Focal Length	FL_x	(cm)		-	0.0	-		(a)
		FL_y	(cm)		-	3.4	0.0		(a)
	$I_{pa.a}@$ MI_{max}	Ipa.3@ Mimax	(W/cm^2)	0					
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		SV depth	(cm)	-	-	-	-	-	(a)
		Velocity	(m/sec)	Max.	-	Max.	-	Max.	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Transducer Model: 6D

Operating Mode: CW

Index Label				MI	TIS			TIB	TIC
					scan	non-scan		non-scan	
						$A_{aprt} \leq 1$	$A_{aprt} > 1$		
Maximum Index Value				0.02	-	0.1	-	0.2	(a)
Assoc. Acoustic Param.	IEC	FDA	Units						
	P_{ra}	Pr.3	(MPa)	0.0					
	P	W(0)	(mW)		-	2.5		2.5	(a)
		LPP	(mW)				-		
	Z_s	Z(1)	(cm)				-		
	Z_{bp}	Z(bp)	(cm)				-		
	z_b	Z(sp)	(cm)	0.2				0.2	
	$Z@I_{pi.a}$ max	Z(sp)	(cm)						
	d_{eq} (Z_b)	d_{eq} (Z_{sp})	(cm)					0.26	
	f_{awf}	f(c)	(MHz)	5.0	-	5.0	-	5.0	(a)
	Dim of A_{prt}	X	(cm)		-	0.3	-	0.3	(a)
		Y	(cm)		-	0.6	-	0.6	(a)
Other Info	t_d	PD.	(ms)	CW					
	prr	PRF	(Hz)	CW					
	$p_r@I_{pi}$ max	P_r@ P||max	(MPa)	0.0					
	$d_{eq}@I_{pi}$ max	d(eq)@ P||max	(cm)					0.26	
	Focal Length	FL_x	(cm)		-	2.5	-		(a)
		FL_y	(cm)		-	2.5	0.0		(a)
	$I_{pa.a}$@ MI_{max}	Ipa.3@ Mimax	(W/cm^2)						
Operator Control		Power	(dB)	0	-	0	-	0	(a)
		Range	(cm)	5.0	-	5.0	-	5.0	(a)
		SV depth	(cm)	-	-	-	-	-	(a)
		Velocity	(m/sec)	Max.	-	Max.	-	Max.	(a)

a. No data are reported for this operating condition since the global maximum index value is not reported for the reason listed

Chapter 2
Electromagnetic Compatibility

Vivid *i* is intended for use in the electromagnetic environment specified in the tables below.

The user of Vivid *i* should assure that the device is used in such an environment.

Guidance and manufacturer's declaration – electromagnetic emissions.		
Emissions test	**Compliance**	**Electromagnetic environment - guidance**
RF emission CISPR 11 EN55011:1998 + A1:1999	Group 1	Vivid *i* uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emission CISPR 11 EN55011:1998 + A1:1999	Class B	Vivid *i* is suitable for use in all establishments, other than domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emission IEC 61000-3-2:2000	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3:1995 +A1:2001	Complies	

Guidance and manufacturer's declaration – electromagnetic immunity.			
Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment - guidance**
Electrostatic discharge (ESD) IEC 61000-4-2:1995 +A1:1998+A2:2001	± 6 kV contact ± 8 kV air	± 6 kV ± 8 kV	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %.
Electrostatic transient / burst IEC 61000-4-4:1995 +A1:2001+A2:2001	± 2 kV for power-supply lines ± 1 kV for input/output lines	± 2 kV ± 1 kV	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5:1995 +A1:2001	± 1 kV differential mode ± 2 kV common mode	± 1 kV ± 2 kV	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11:1994 A1:2001	< 5 % U_T (>95 % dip in U_T) for 0,5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles < 5 % U_T (>95 % dip in U_T) for 5 sec	Compliance for all test levels. Controlled shutdown with return to pre-disturbance condition after operator's intervention. (Power-on switch)	Mains power quality should be that of a typical commercial or hospital environment. If the user of Vivid *i* requires continued operation during power mains interruptions, it is recommended that Vivid *i* is powered from an uninterruptible power supply or a battery.

Power frequency (50/60 Hz) magnetic field IEC 61000-4-8:1993 +A1:2001	3 A/m	3A/m 50 and 60Hz	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
NOTE U_T is the a. c. mains voltage prior to application of the test level.			

Guidance and manufacturer's declaration – electromagnetic immunity.			
Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment – guidance [c]**
Conducted RF IEC 61000-4-6:1996 +A1:2001	3 Vrms 150 kHz to 80 MHz	3 Vrms [V_1]	Portable and mobile RF communications equipment should be used no closer to any part of Vivid *i*, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance $d = [\frac{3,5}{V_1}]\sqrt{P}$ $d = [\frac{3,5}{E_1}]\sqrt{P}$ 80 MHz to 800 MHz $d = [\frac{7}{E_1}]\sqrt{P}$ 800 MHz to 2,5 GHz where *p* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and *d* is the recommended separation distance in metres (m).[b] Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b] Interference may occur in the vicinity of equipment marked with the following symbol: 
Conducted RF IEC 61000-4-3:1996 +A1:1998+A2:2001	3 V/m 80 MHz to 2.5 GHz	3V/m [E_1]	
NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic is affected by absorption and reflection from structures, objects and people.			

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/ cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which Vivid *i* is used exceeds the applicable RF compliance level above, Vivid *i* should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating Vivid *i*.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

[c] See examples of calculated separation distances in next table.

Recommended separation distances between portable and mobile RF communications equipment and Vivid *i*			
Vivid *i* is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the Vivid *i* can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and Vivid *i* as recommended below, according to the maximum output power of the communications equipment			
Rated maximum output of transmitter W	**Separation distance according to frequency of transmitter m**		
	150 kHz to 80 MHz $d = [\frac{3,5}{V_1}]\sqrt{P}$	80 MHz to 800 MHz $d = [\frac{3,5}{E_1}]\sqrt{P}$	800 MHz to 2,5 GHz $d = [\frac{7}{E_1}]\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23
For transmitters rated at a maximum output power not listed above the recommended separation distance d in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer. NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

Appendix

This chapter includes the following information:

Statements on the safety of ultrasound

AIUM Statement on Clinical Safety

October 1982, revised March 1983 and October 1983

Diagnostic ultrasound has been in use for over 35 years. Given its known benefits and recognized efficacy for medical diagnosis, including use during human pregnancy, the American Institute of Ultrasound In Medicine herein addresses the clinical safety of such use:

No confirmed biological effects on patients or instrument operators caused by exposure at intensities typical of present diagnostic ultrasound instruments have ever been reported. Although the possibility exists that such biological effects may be identified in the future, current data indicate that the benefits to patients of the prudent use of diagnostic ultrasound outweigh the risks, if any, that may be present.

AIUM Statement on Mammalian *in Vivo* Ultrasonic Biological Effects

August 1976, revised October 1978, reaffirmed October 1982 and October 1983

In the low megahertz frequency range there have been (as of this date) no independently confirmed significant biological effects in mammalian tissues exposed to intensities"a" below 100 mW/cm^2. For ultrasound exposure times "b" less than 500 seconds and greater than 1 second, such effects have not been demonstrated even at higher intensities when the product of intensity "a" and exposure time "b" is less than 50 Joules/ cm^2.

1. Spatial peak, temporal average as measured in a free field in water.
2. Total time, this includes off-time as well as on-time for a repeated pulse regime.

Medical Ultrasound Safety - AIUM

Track 3 ALARA Educational Program

The user should be familiar with the enclosed document “Medical Ultrasound Safety”, published by AIUM (American Institute of Ultrasound in Medicine).
This document is acceptable to FDA as meeting the content of the ALARA educational program.
ALARA is an acronym for the principle of prudent use of diagnostic ultrasound by obtaining the diagnostic information at an output that is **A**s **L**ow **A**s **R**easonably **A**chievable.

In addition to the AIUM document, the sections “The real-time display of acoustic output indices” and “Acoustic Output Operating Controls” should be studied carefully in order to implement ALARA

Medical Ultrasound Safety

Part One: Bioeffects and Biophysics

Part Two: Prudent Use

Part Three: Implementing ALARA

American Institute of Ultrasound in Medicine

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Preface

With the availability of an output display in some present and in future diagnostic ultrasound equipment and the potential for higher output capabilities within these devices, it is incumbent upon the user to be knowledgeable of the uses of this equipment and the potential for ultrasound-induced bioeffects. The responsibility for patient safety is falling more heavily upon the ultrasound equipment user's shoulders and the need for an educational background in these uses and bioeffects is evident. In other words, there is a shift in responsibility for patient safety from the manufacturer to the user. In this regard, this tripartite brochure has been generated to provide the user with a working background and general principles that will provide for the understanding of the purpose and use of the Output Display Standard and how this display can be used to obtain diagnostic information with ultrasound exposure as low as reasonably achievable. The user education requirement represents a new level of responsibility that will permit increased ultrasound diagnostic capabilities within the context of user controlled ultrasound exposure. Information regarding ALARA and possible ultrasound bioeffects described in this brochure also applies to equipment without an output display.

Michael S. Tenner, M.D.

AIUM President

Introduction

A new feature, called an output display, is becoming available on some recently introduced and future diagnostic ultrasound equipment. The output display provides the user an indication of the potential for bioeffects that might be caused by the ultrasound energy being emitted. With this information, users can better control the diagnostic ultrasound equipment and examination to assure that needed diagnostic information is obtained with a minimum o risk to the patient.

To get the most benefit from the output display, the user should have a basic understanding of the nature of ultrasound-induced bioeffects, how to conduct an exam that minimizes the potential for bioeffects, and how to operate the controls of the equipment used in the exam.

This brochure is divided into three parts. Part One describes ultrasound-induced bioeffects and why we should be concerned about them. Part Two describes the risks and benefits of conducting diagnostic examinations and introduces the concept of ALARA, that is, ultrasound exposure As Low As Reasonably Achievable. Using ALARA, we can obtain needed diagnostic information with minimum risk to the patient. Part Three describes how to implement ALARA on equipment with and without an output display. With an output display, we have the best information about the potential for bioeffects and can make the best decisions.

Each manufacturer’s equipment has somewhat different control features. This brochure can only provide general principles about ALARA and diagnostic ultrasound equipment. Please refer to the user documentation for your particular equipment to learn the details of its particular controls and output displays.

Acknowledgements

The development of this Ultrasound Education Program brochure went through a number of style and format changes and involved dedicated professionals from a number of organization over the past three years. Initially, three videotapes were planned with the creation of three scripts. What finally emerged is this brochure. There are many individuals to thank. Special recognition is given to Mr. Chas Burr for his extensive revisions to the final content of the text. Without their assistance, this brochure would not have been possible.

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Part One

Bioeffects and Biophysics

"Diagnostic ultrasound has proven to be a valuable tool in medical practice. An excellent safety record exists in that, after decades of clinical use, there is no known instance of human injury as a result of exposure to diagnostic ultrasound. Evidence exists, however, to indicate that at least a hypothetical risk for clinical diagnostic ultrasound must be presumed."

Radiological Health Bulletin,
Vol XXIV, No. 8,
August 1990

Chapter One

Is It Safe?

Issues Addressed

- Why it is important to know ultrasound physics
- What dose-effect studies tell us
- Mechanisms of ultrasound-induced biological effects
- History of ultrasound
- Prudent use

Everyone thinks ultrasound is safe.

Q. Everyone thinks that ultrasound is safe. We keep hearing, “no known instance of human injury as a result of exposure to diagnostic ultrasound.” So why do we have to learn about biophysics and bioeffects?

There is a potential risk.

A. When ultrasound propagates through human tissue, there is a potential for tissue damage. There has been much research aimed at understanding and evaluating the potential of ultrasound to cause tissue injury. Through these studies, we are trying to learn what causes ultrasonic bioeffects and apply that information to diagnostic ultrasound. Many studies are dose-effect studies. These laboratory studies give us two things: First, they provide an opportunity to use much higher dosage levels than those currently used in a diagnostic ultrasound exam to really test the safety of ultrasound, and second, they permit a detailed study of mechanisms thought to be responsible for bioeffects.

Q. So dose-effect studies are performed at higher intensities than diagnostic ultrasound?

Dose-effect studies

A. Much higher levels. In fact, virtually all ultrasonically induced adverse biological effects have occurred at these higher intensity levels.

Q. What's been learned from the dose-effect studies?

Thermal Mechanism
Nonthermal Mechanism

A. So far, we've deduced that two mechanisms are known to alter biological systems. One, called the "Thermal Mechanism," refers to heating of soft tissue and bone. the other, "Nonthermal," involves mechanical phenomena such as cavitation, although nonthermal mechanisms are more than cavitation alone. You can think of cavitation as the interaction of ultrasound with tiny bubbles in tissue and liquids.

History of ultrasound

Q. How long have we known of the potential of ultrasound?

A. In 1880, two French scientists, Jacques and Pierre Curie, discovered piezoelectricity, the basis for ultrasonic transducers. About thirty-five years later, another French scientists named Paul Langevin developed one of the first uses of ultrasound, underwater sound-ranging of submerged objects known today as sonar. In the process he discovered and reported that very high-intensity ultrasonic levels could have a detrimental effect on small aquatic animals.

Ten years later, scientists Wood and Loomis conducted experiments that substantiated Langevin's observation. Then, in 1930, Harvey published a paper about the physical, chemical, and biological effects of ultrasound, reporting that alterations were produced in a variety of organisms, cells, tissue, and organs. Long before anyone even though of using ultrasound to produce images of the human body, it was already known that high levels of ultrasound were hazardous. With this in mind, early pioneering engineer and clinicians who were designing ultrasound imaging devices knew about the potential for disrupting biological tissue.

Thus, there has been concern about potential harmful effects throughout the entire period of diagnostic instrumentation development.

If there's a potential for bioeffects...

Q. If there's a potential for bioeffects, why do we use ultrasound?

No patient injury has ever been reported from diagnostic ultrasound.

A. Most important, we use ultrasound because of its many diagnostic uses and benefits. Although there may be a risk, there has never been a documented instance of a patient being injured from this diagnostic modality.

Q. If there is a potential for ultrasound-caused bioeffects, why has there been such a good safety record?

A. As the uses of medical devices have grown and more application areas and equipment have been developed, regulations have been enacted to provide for patient safety concurrent with equipment development. In 1976, the Medical Device Amendments to the Food, Drug, and Cosmetic Act were enacted, requiring the Food and Drug Administration (FDA) to regulate all medical devices, including diagnostic ultrasound equipment. The FDA has required manufacturers of diagnostic ultrasound equipment to keep acoustic output below that of machines on the market before 1976, the year the amendments were enacted. Manufacturer bringing new products to the market must compare the various performance characteristics of ultrasound equipment, including acoustic output, to devices previously approved for marketing.

"... the benefits to patients of the prudent use of daignostic ultrasound outweigh the risks, if any, that may be present."

Within these “limits,” ultrasound has been shown itself to be a safe and effective diagnostic tool for medical application. But it is important to remember that the pre-1976 output levels are based in history, not on scientific safety evaluations.

In March 1993, the American Institute of Ultrasound in Medicine approved the Official Statement on Clinical Safety:

“*Diagnostic ultrasound has been in use since the late 1950w. Given its known benefits and recognized efficacy for medical diagnosis, including use during human pregnancy, the American Institute of Ultrasound in Medicine herein addresses the clinical safety of such use: No confirmed biological effects on patients or instrument operators caused by exposure at intensities typical of present diagnostic ultrasound instruments have ever been reported. Although the possibility exists that such biological effects may be identified in the future, current data indicate that the benefits to patients of the prudent use of diagnostic ultrasound outweigh the risks, if any, that may be present.”*

(From *Bioeffects and Safety of Diagnostic Ultrasound,* published in 1993 by the American Institute of Ultrasound in Medicine)

Q. Why is there more discussion of ultrasound safety now than in the past?

History of ultrasound in medicine

A. The question of safety is being discussed more because more and more applications are being found, and the industry is producing technically sophisticated devices that provide more diagnostic information. Current dialogue among the medical community, manufacturers, and the FDA suggests that new standards recently developed should allow higher outputs for greater diagnostic capability. This will improve some imaging and Doppler situations, but with greater risk and greater operator responsibility.

Higher outputs bring potentially greater risk.

Just because we haven't detected bioeffects on humans at diagnostic levels, doesn't mean that they don't exist. We know the potential for risk exists. It's important for ultrasound users to know about biophysics and bioeffects so they can make informed decisions about the use of ultrasound and can reduce the chances of bioeffects occurring. In the future, more and more decisions about the use of ultrasound output levels will be made by equipment operators.

Prudent use

The use of ultrasound in medicine began in the 1950s. At that time, the number of applications was rather limited. The uses for ultrasound grew in the 1950s, adding applications such as cardiology, obstetrics, gynecology, vascular, ophthalmic, and the imaging of regions of the body, such as the female breast and male pelvis. By the early 1960s most of the basic ultrasound applications used today had been attempted, although with much less diagnostic content than today. Clinical use continues to grow during the 1970s with the introduction of real-time scanning.

Early exams were conducted entirely through the skin surface, but intracavitary and intraoperative applications have undergone a recent surge as manufacturers and clinicians seek to expand the diagnostic potential of ultrasound. Today, the clinical uses for ultrasound are many and varied, and diagnostic ultrasound is one of the fastest growing imaging techniques in medicine. Surveys in the United States indicate that a very high percentage of pregnant women are scanned to obtain fetal health information. There are about 100 thousand medical ultrasound scanners in use worldwide. This equipment handles millions of examinations each year. And, the number continues to grow.

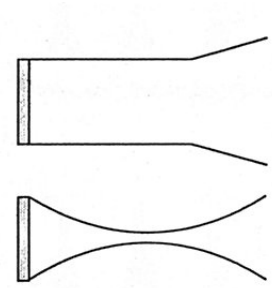
Chapter Two

Thermal Bioeffects

Issues Addressed

- Focused and unfocused ultrasound fields
- Spatial and temporal considerations
- Attenuation, absorption, and scattering
- Soft tissue, layered and fetal bone models
- Soft tissue, layered and fetal bone heating
- Axial temperature increase profiles

Q. If ultrasound causes tissue temperature to rise, where is the largest temperature rise found?



Unfocused and focused ultrasound fields.

A. The highest temperatures tend to occur in tissue in the region between where the ultrasound beam enters tissue and the focal region.

Because the temperature elevation is related to both ultrasonic power and the volume of exposed tissue, we need to keep in mind whether the beam is scanned or unscanned, in other words, whether the equipment moves the beam or keeps it stationary. Scanned modes, such as B-mode imagine and color flow Doppler, distribute the energy over a large volume. In scanned modes, the highest temperature is frequently at the surface where the ultrasound enters the body.

Unscanned modes, such as spectral Doppler and M-mode, concentrate the power along a single line in the patient and deposit energy along the stationary ultrasound beam. Energy is distributed over a much smaller volume of tissue than in the scanned case. In unscanned modes, the highest temperature increase is found between the surface and the focus. In other words, the hottest point is found between the surface of the beam and proximal to the focal point, but not at the focal point. The exact location depends on the tissue attenuation and absorption properties and the beam's focal length. For long focal lengths, the location of the maximum temperature elevation may lie closer to the surface, but for short focal lengths, it is generally closer to the focus.

Spatial considerations

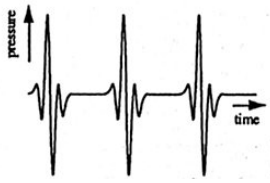
Intensity = Power / Area

Q. Focusing the ultrasound beam increases the temperature?

A. Focusing concentrates the power in the beam on a small area, thereby improving image lateral resolution, but also causing higher intensities and the potential for higher temperatures.

Temporal considerations

Q. What other aspects of the ultrasound beam effect the temperature?



Pulsed pressure waveform

A. An important aspect is time.

Ultrasonic waves can be emitted in pulsed wave form. There's a burst of energy, then, there's a period of silence. Then, there's another pulse and more silence, and on and on. During the pulse the acoustic intensity is high, but during the silence the intensity is zero.

Pulsed intensity waveform

If we take the entire repeating time period, both the pulse and the silence, and average the intensity that may be a thousand times smaller than the instantaneous or temporal-peak intensity that occurs once during the pulse. Bioeffects resulting from temperature increases depend, in part, on the temporal-average intensity.

Temperal-average (TA) and temporal-peak (TP) intensities

The intensity at the location of the greatest temporal-average intensity is referred to as the spatial-peak temporal-average intensity: SPTA. The SPTA is often used as a specification of ultrasound output.

Ultrasound exposure duration

In addition to time averaging, there's another time concept that affects temperature increase: duration of the ultrasound exposure, or how long one location is imaged during an examination. It takes time for tissue temperature to rise, and the longer the exposure duration, the greater the possibility of a biological effect.

Q. What causes temperature rise in tissue during ultrasonic exposure?

A. The absorption of energy. During an exam, much of the ultrasound energy is absorbed by body tissue. If the rate of energy deposition in a particular region exceeds the body's ability to dissipate the heat, the local temperature will rise.

Attenuation
1. Absorption = energy converted to heat
2. Scattering = redirection of ultrasound

Absorption and attenuation are often confused. Attenuation is the loss of energy from the propagated ultrasound wave. There are two causes for attenuation: Absorption and scattering. Absorption is the conversion of ultrasonic energy into heat; whereas, scattering is the redirection of ultrasound away from the direction it was originally traveling.

Absorption of acoustic energy by tissue results in the generation of heat in the tissue. This is what is referred to as the thermal mechanism. There are a number of physical and physiological variables that play a role in absorption and the generation of temperature increases. Some, of course, are the operating characteristics of the equipment. For now, let's concentrate on physical parameters.

Attenuation coefficient and absorption coefficient have the same units – dB/cm or dB/cm-MHz

Q. What are some of the physical parameters that affect absorption?

A. The ultrasound energy is absorbed by tissue, at least to some extent. The extent depends on the tissue, on what we call tissue absorption characteristics.

Increasing Attenuation:
Coefficient
Water
Biological fluids
Soft tissues
Skin and cartilage
Fetal bone
Adult bone

A specific way in which tissue absorption characteristics are quantified is with the "Absorption Coefficient." The absorption coefficient is expressed in decibels per centimeter. Since absorption coefficient is directly proportional to ultrasonic frequency, the coefficient is often normalized to frequency and represented as decibels per centimeter per megahertz. Absorption coefficients are very dependent on the organ or tissue type that is being imaged.

Q. Let's get some examples. What's the absorption coefficient of, say, fluids, like amniotic fluid, blood, and urine?

A. Almost zero. There fluids absorb very little ultrasonic energy. That mean the ultrasound goes through the fluid with very little decrease. And there's little temperature elevation in the fluid.

Q. Which body tissue absorbs the most energy?

A. Bone. Its absorption coefficient is very high. Dense bone absorbs the energy very quickly and causes the temperature to rise rapidly. Adult bone absorbs nearly all of the acoustic energy impinging on it. Fetal bone absorption coefficients vary greatly depending on the degree of ossification.

Q. Now what's between fluid and bone?

Homogeneous soft tissue model

A. Soft tissue. Tissues vary in density depending on the particular organ, but the density doesn't vary much within an organ. We call it soft to distinguish it from hard tissue such as bone. It's also true that the tissue density within a particular organ is not always the same. But, for our purposes we assume that attenuation and absorption are uniform throughout the organ. We call this a homogeneous soft tissue model.

Q. How does frequency affect absorption?

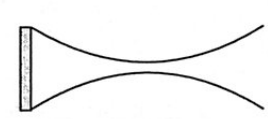
A. The higher the frequency, the higher the absorption. What that means to operators is that a higher-frequency transducer will not allow us to "see" as far into the body.

Higher Frequency = Increased Absorption, Reduced Penetration, Possible Near Surface Heating

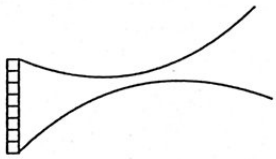
Q. Does that mean that higher-frequency transducers create more heat?

A. Not necessarily. There are many factors that contribute to creating heat. However, if all other factors are equal, the ultrasound energy of higher-frequency transducers is absorbed more rapidly than that of lower-frequency transducer, thereby causing reduced penetration. In some cases, this may introduce increased heating near the skin surface.

However, sue to the rapid absorption of higher-frequency ultrasound, there's another indirect effect that might occur. If we're not getting deep enough, we might choose to increase the output, and the increased intensity could also increase temperature.



Fixed-focus transducer



Multi-element array transducer

Q. Now let's talk about what all this means in practical terms. What is the situation of most interest?

A. The situation of greatest interest involved the fetus with ossified bone (second and third trimester) and a mother with a thin abdominal wall. Because there would be little absorption of energy between the transducer and the fetus, nearly all of the energy would be absorbed by a fetal bone, if the beam is focused on or close to it.

Q. What can we as operators do to minimize temperature rise?

A. First, temperature increases depend on intensity, duration of exposure at the same location, transducer focal point size and location, and absorption of the energy by the tissue. In general, intensity is alterable, and depends on the particular equipment we're using. As the operator, we can also control duration, or exposure time. The transducer is typically moved frequently during the exam, which will naturally reduce the exposure duration at a specific tissue location.

Let's look at the other two factors: transmit focal point and absorption. A highly focused beam whose focal point is in the amniotic fluid will not cause significant heating of the fluid, because its absorption coefficient is low. If the focus is in tissue, all things being the same, the temperature rise is a little higher. However, the same beam will cause an even higher temperature rise time if it occurs on bone, which has a much higher absorption coefficient. Be aware that there are fixed-focused transducer whose focus we can't change and multi-element array transducers whose focus we can change.

The other important determinant of local temperature rise is absorption of ultrasound energy in tissue layers in front of the point of interest. Increased absorption in these layers decreases the ultrasound energy available at the point of interest. For example, an obstetrical examination of a patient with a thick abdominal wall is less likely to cause a significant temperature increase in the fetus than an examination through a thin abdominal wall.

Q. What are some examples of temperature increase calculations?

A. We have computer models that predict the relationship between transducer focus and changes in the temperature curve.

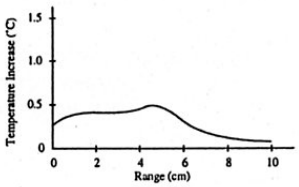
Computer Tissue Models

- Homogeneous Soft Tissue Model
- Layered Tissue (Fluid-filled Bladder) Model
- Fetal Bone Model

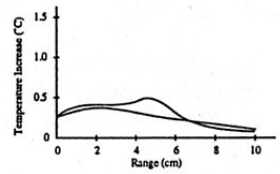
Assumptions

- Speed of Sound Is Uniform Throughout
- Attenuation Is Uniform Throughout
- Absorption is Uniform Throughout
- Absorption Equals Attenuation (Scattering is negligible)

Modeling various tissue layers is difficult since there are so many. We focused on two simplified models. In the first, ultrasound travels through homogeneous soft tissue. In the second, ultrasound travels through a fluid-filled bladder. We assumed that the speed on sound, acoustic impedance, attenuation, and absorption are uniform throughout the volume of interest.



Homogeneous soft tissue model: axial temperature increase profile for a transmit focal length of 6 cm



Homogeneous soft tissue model: axial temperature increase profile for a transmit focal length of 6 and 10 cm

Transducer

- 3.0 MHz
- 19 mm diameter
- 6 cm transmit focal length
- 100 m W output ultrasonic power

We also selected a 3.0 MHz, 19 mm diameter transducer with a 6 cm transmit focal length. For convenience, we have used an ultrasonic output of today's diagnostic equipment, only found in some Doppler and color Doppler modes. Keep in mind, these models are for educational purposes and may not reflect actual clinical situations.

Homogeneous Tissue Model: Abdominal Exam

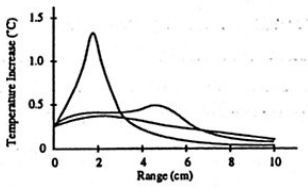
First, let's look at the homogeneous tissue model. This model is similar to the situation in an abdominal exam involving soft tissue only. The temperature increase in degrees Celsius goes up the left side of the figure. The range in centimeters goes across the bottom of the figure.

We'll see that the temperature increase exhibits a maximum at about five centimeters.

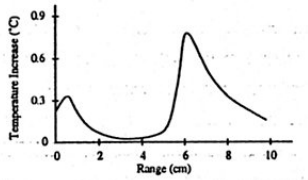
For the next scenario, all we'll change is the focal point location. We just saw the 6 cm focal length. Now, let's see what the same transducer does in the same tissue with a 10 cm focal length. It flattens out quite a bit, doesn't it?

But look at what happens if the focal length is 2 cm. The temperature goes way up to about 1.3ºC at a range of about 2 cm. What does that mean? It means that a significant increase in temperature near the beam's focus is more likely with shorter focal lengths because less overall attenuation of the beam has occurred.

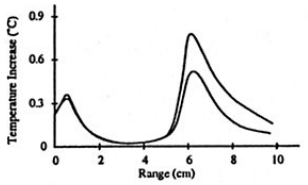
Now, let's look at this in a situation similar to an obstetrical exam.



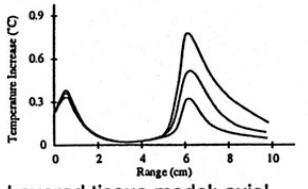
Homogeneous soft tissue model: axial temperature increase profiles for transmit focal lengths of 2, 6, and 10 cm



Layered tissue model: axial temperature increase profile for a transmit focal length of 6 cm



Layered tissue model: axial temperature increase profile for transmit focal lengths of 6 and 10 cm.



Layered tissue model: axial temperature increase profile for transmit focal lengths of 4, 6 and 10 cm.

Layered Tissue Model: Obstetrical Scam

- Abdominal wall thickness = 1 cm
- Bladder fluid path = 5 cm

For this situation, we have a layered tissue model based on an obstetrical scan through the abdominal wall and through the fluid-filled bladder of the fetus. For the scenario, we assumed a patient with a thin abdominal wall of 1 cm and a 5 cm fluid path. The transducer and its ultrasonic power are the same as those used in the homogeneous tissue cases. The transmit focal length of 6 cm is at the location of the far side of the bladder and note that the temperature goes up about 0.8ºC at this range. Also note, the increase in temperature in the abdominal wall is about 0.4ºC There's almost no absorption of ultrasound in the bladder fluid, so little heat is produced there.

Now here's the axial temperature increase profile in the layered tissue model for a longer focal length of 10 cm. The temperature rise at the far side of the bladder is about 0.5ºC, a drop from when the ultrasound beam was focused at the location.

Let's look at a situation where the beam focuses in front of the far side of the bladder, at a 4 cm transmit focal length. The temperature rise at the far side of the bladder is about 0.3ºC, also a drop from when the ultrasound beam is focused at that location. Note that the increase in temperature in the abdominal wall is about 0.4ºC for all three focal length conditions.

That means if the transmit focus location occurs before the target, then the temperature rise at the far side of the bladder, at a range of 6 cm for this layered tissue model, is less than if the focus is at or beyond the target, where the temperature elevation at the target is higher.

Fetal Bone Model

- Homogeneous Soft Tissue Parameters
- Bone Location at 6 cm in Range
- 100 mW Output Ultrasonic Power

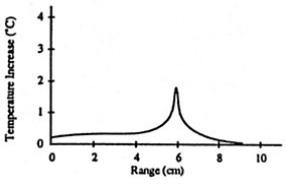
Let's see what happens when we focus near bone. For this model, we'll use the homogeneous soft issue parameters for the tissues through which the beam passes, but our reflective surface is bone that is perpendicular to the beam at a range of 6 cm. We will also use the same output ultrasonic power of

100 mW. When the transmit focal range is beyond the location of bone, focal range of 10 cm, there is a peak in the temperature increase to about 1.9ºC at the bone location.

Here's what happens with a transmit focal length of 6 cm, that is, the ultrasound beam is focused on the bone surface: a theoretical temperature rise of about 4.2ºC.

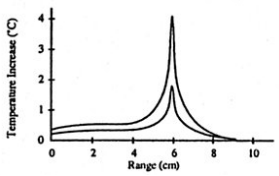
Q. How does all this apply to actually scanning a patient? Is this dangerous?

A. Potentially dangerous. The examples we looked at are for educational purposes and do not necessarily occur in clinical situations. For example, the output power used for the calculation would not be commonly used, but it is within the capability of many systems.



Fetal bone model: axial temperature increase profile for a transmit focal length of 10 cm

Temperature rise during an actual examination depends on many factors. For example, very few patients have as thin an abdominal wall as we assumed in this model. In addition, the exposure to bone must be continuous over time for local temperatures to rise. That seldom happens in actual exams. Plus, some heating is lost due to the cooling effect of local blood flow. To date, there is no evidence of any harm in humans from thermal effects at the output levels of current ultrasonic devices.



Fetal bone model: axial temperature increase profile for transmit focal lengths of 6 and 10 cm

Q. But if it’s potentially dangerous, why hasn’t there been an incident?

A. The combined conditions required to produce these heating effects are unlikely to occur. In addition, the control parameters on current equipment are designed to limit the temporal-average intensity. By minimizing temporal-average intensity, significant thermal effects in the body are not likely to occur. However, it is unclear what output levels will be used in future applications and equipment.

Abdominal wall thickness, Focal length and location, Exposure duration, Bone attenuation, Tissue attenuation, Bone absorption, and Tissue absorption

The goal is to get an image that provides necessary diagnostic information.

The goal is to get an image that provides necessary diagnostic information. If we are overly cautious, we may end up with poor image quality or inadequate Doppler signals. For operators to minimize the risk, we need to understand the factors that contribute to temperature rise, for example, the thickness of the mother’s abdominal wall, the beam focal length and location, exposure duration, and the attenuation and absorption characteristics of tissue and bone.

Chapter Three

Nonthermal Bioeffects

Issues Addressed

- Onset of Cavitation
- Peak compressional pressure
- Peak rarefactional pressure
- Stable cavitation and transient cavitation
- Microstreaming
- Nucleation site
- Threshold phenomenon

Q. Nonthermal bioeffects means bioeffects not caused by temperature rise. That tells us what they are not. Exactly what are nonthermal bioeffects?

A. Nonthermal bioeffects are not as well understood as thermal effects. They are sometimes referred to as mechanical bioeffects because they seem to be caused by the motion of tissue induced when ultrasound pressure waves pass through or near gas. The majority of the nonthermal interactions deal with the generation, growth, vibration, and possible collapse of microbubbles within the tissue. This behavior is referred to as cavitation.

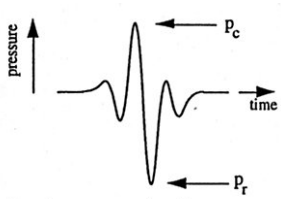
Cavitation was first discovered around the turn of the century, not is tissues, but at the surface of a ship's propellers. Researchers found that the low-pressure region immediately behind a ship's propellers caused bubbles to be produced in the water. The collapsing bubbles damaged the propellers. The bubbles collapsed violently, generating shock waves that eroded the propeller blades.

What is cavitation – bubbles?

Q. So cavitation is bubbles?

A. With diagnostic ultrasound, cavitation refers to ultrasonically induced activity occurring in tissues or body liquids that contain bubbles or pockets containing gas or vapor. These bubbles originate within materials at locations termed "nucleation sites," the exact nature and source of which are

not well understood in a complex medium such as tissue or blood.



Peak compressional pressure (p_c) and peak rarefactional pressure (p_r)

A sound wave has positive pressure and negative pressure. Positive pressure is also called compressional pressure; negative pressure is also called rarefactional pressure. If the rarefactional pressure is sufficiently large, microbubbles may be produced, or existing microbubbles may be enlarged.

Q. When does cavitation occur?

Cavitation depends on
- frequency
- pressure
- focused/unfocused beams
- pulsed/continuous ultrasound
- degree of standing waves
- nature and state of material
- boundaries

A. The occurrence of cavitation and its behavior may depend on many factors, including the ultrasonic pressure and frequency, the focused or unfocused and pulsed or continuous ultrasonic field, the degree of standing waves, and the nature and state of the material and its boundaries.

Q. Is cavitation related to SPTA intensity?

A. No. The correlation is not with temporal-average intensities, but rather with pressure. Cavitation is most closely related to peak negative pressure, or peak rarefactional pressure, during the pulse.

Cavitation is related to the peak rarefactional pressure.

Peak negative pressure is roughly related to the pulse-average intensity. So, the spatial-peak pulse-average intensity, the SPPA intensity, is loosely related to cavitation. This relationship is useful to us because many existing ultrasound systems use SPPA intensity as a specification or control.

Cavitation
1. Stable
2. Inertial (or Transient)

Q. Are there different types of cavitation?

A. Cavitation can be discussed in terms of two categories: stable cavitation and inertial (or transient) cavitation.


Oscillating bubble and microstreaming

Stable cavitation is associates with vibrating gaseous bodies. In stable cavitation a gaseous body remains stabilized and, because of the ultrasonic field, oscillates or pulsates. As the oscillations become established, the liquid-like medium around the gas bubble begins to flow or stream; we call this “microstreaming.” Microstreaming has been shown to produce stress sufficient to disrupt cell membranes.

During inertial cavitation, pre-existing bubbles or cavitation nuclei expand from the pressure of the ultrasonic field and then

collapse in a violent implosion. The whole process takes place in a very short time span that is on the order of microseconds. The implosion can produce huge local temperature rises that may be thousands of degrees Celsius, and pressure equal to hundreds of atmospheres all in an area that is less than one square micrometer. The implosion can damage cells and tissue, ultimately leading to cell death. In addition, bubble implosion can generate highly reactive chemical species. All of these effects, microstreaming, implosion, and reactive chemicals occur in a very small space around the bubble, affecting only a few cells.

Q. Is it really possible for cavitation to occur at the amplitudes and frequencies used for diagnostic ultrasound?

A. Perhaps, if nuclei sites are available. There is ample theoretical and some experimental evidence to support this conclusion, and that biological alterations can occur. We are fortunate to have this evidence because it documents the levels above which cavitation is though to occur, and because there is a lot of scientific evidence to suggest that the onset of transient cavitation is a threshold phenomenon.

There's a combination of rarefactional pressure values, ultrasonic frequency, and cavitation nuclei that are required for cavitation to occur. If, as evidence suggests, cavitation is a threshold phenomenon, then exposure to pressure levels below the threshold for cavitation will never induce cavitation, no matter how long the exposure lasts.

Can cavitation be produced by diagnostic ultrasound exposure?

Q. Do we know of any incidence of cavitation occurring in human tissue or fluids resulting from diagnostic ultrasonic exposure?

A. Currently, there is no evidence that diagnostic ultrasound exposure has caused cavitation in humans.

In addition, the control parameters on current equipment limit the peak output. However, limits may be raised or eliminated in future equipment.

Q. But, theoretically, it can happen?

A. Yes. but since cavitation would probably affect only a single cell, or a few cells, it is extremely difficult to detect an adverse biological effect, unless the cavitation events were widespread among a large volume of tissue.

Part Two

Prudent Use

"Although the possibility exists that such biological effects may be identified in the future, current data indicate that the benefits to the patient of the *prudent use* of diagnostic ultrasound outweigh the risks, if any, that may be present."

American Institute of Ultrasound in Medicine

Official Statement On Clinical Safety

March 1993

Chapter Four

Benefits and Risks

Issues Addressed

- Risks versus benefits
- Diagnostic ultrasound benefits
- Risk of not performing the study
- Prudent use
- New technology and applications
- High output, potentially greater risk
- High output, potentially greater diagnostic capability
- Shifting responsibility

Risks vs. benefits

Q. “Risk versus benefits.” What do we mean by that in terms of ultrasound?

A. The risks are the potential for adverse bioeffects caused by heating or cavitation. Although there has not been a reported incident of serious bioeffects on humans at diagnostic ultrasound levels, we do know that heating of the tissue may occur and there may be the potential for cavitation to occur.

The benefit is the diagnostic information ultrasound provides. And ultrasound imaging provides very good data, data that allow physicians to make clinical decisions. With information from an ultrasound exam, physicians can weigh alternative courses of action and select the best method for helping the patient.

Ultrasound imaging is popular first and foremost because it’s a superb diagnostic modality. It provides tremendous diagnostic information with great sensitivity and specificity. But it’s also a favorite imaging technique because it appears safe, is widely accepted by patients, is portable, and is relatively low in cost compared to other diagnostic imaging modalities. Physicians must weigh the expected benefit from a diagnostic ultrasound procedure against the potential risks of that procedure.

Q. What are some examples of the benefits of diagnostic ultrasound?

Examples of benefits from diagnostic ultrasound: Cardiac studies

A. Let's look at ultrasound in cardiac studies. The use of diagnostic ultrasound for cardiac applications has increased dramatically over the past ten years. From M-mode scans to transesophageal echocardiography, ultrasound gives us the ability to image the structure and function of the heart and great vessels in exquisite detail. Ultrasound also has the ability to follow the normal and abnormal course of blood flow within the heart.

Q. How about potential bioeffects with some of the new cardiac applications?

A. Diagnostic ultrasound has an excellent safety record over the years that it's been used to study the heart. The nature of many cardiac ultrasound techniques, the variety of imaging windows, and the fact that the heart is filled with moving blood means that the duration of the exposure of any one area of the heart is reduced.

It's a real risk not to perform the study.

Newer applications of ultrasound through the esophagus and within the vascular space may result in bioeffects we've not previously known about. we need more research before we can define all the risks. But remember, the physician should weigh potential bioeffects against the real risks of not doing the study and missing important timely diagnostic information.

Q. What other medical specialties benefit from ultrasound?

Example of benefits from diagnostic ultrasound: Obstetrical exams

A. Ultrasound has had a huge impact on the area of obstetrics. The use of ultrasound examinations during pregnancy has increased dramatically since the 1970s. The use of ultrasound in obstetrics is a principal area of concern for potential bioeffects. Ongoing studies may provide accurate information based related to potential effects of ultrasound on the embryo-fetus. In fact, the combination of the increase in use and the concern for safety led to the National Institutes of Health consensus development conference in the early 1980s. The conference discussed the use of diagnostic ultrasound in pregnancy. The committee did not recommend routine ultrasound examinations during pregnancy, but they did suggest a number of appropriate clinical indications for the use of ultrasound during pregnancy.

Balancing benefits and risks

Q. How do you balance the benefits and risks?

Ultrasound benefits:
• Many diagnostic uses
• Replaces or used with other procedures
• Cost effective
• Patient acceptance
• High quality information

A. ultrasound imaging during pregnancy is important because it provides a considerable amount of information. On the one hand, ultrasound offers lots of diagnostic uses, may be used to replace some procedures, can be used in conjunction with other procedures, is cost effective, in accepted by patients, and provides a great deal of high quality clinical information.

Prudent use

On the other hand, we have the risks: thermal and nonthermal bioeffects. But there's another risk that must be considered: the risk of not doing the ultrasound exam and either not having the information or having to get it in a less desirable or invasive way. As the American Institute of Ultrasound in Medicine statement says, "...*the benefits to patients of the prudent use of diagnostic ultrasound outweigh the risks, if any, that may be present.*"

New technology and applications

Q. What about the benefits of new ultrasound technology and applications?

A. There has been a virtual explosion of technology and applications over the past few years: new manufacturers, new products, new medical specialties,. and more and more medical applications. Now we have everything from small hand-held Doppler systems to more general imaging systems that display nearly all of the body's soft tissues in detail.

Users assume more responsibility

But it's more that technology; it's what the technology gives us; but instance, better quality images and more diagnostic information. Still, all the operating modes and the varying output levels mean that more responsibility must be assumed by the users.

Diagnostic ultrasound is widely accepted because it is a superb diagnostic tool with an excellent history of safety. We want to keep it that way. But with more and different types of equipment, larger numbers of patients, and all the new applications, there's increased concern about potential bioeffects.

Q. Now that we understand the potential for ultrasound-induced bioeffects, should we change how we use the equipment?

A. We must learn to balance the risks and the benefits. We have learned about bioeffects: thermal effects, or tissue heating; and mechanical effects, such as cavitation. We learned how intensity, exposure time, focal properties, and pressure are associated with the risk for bioeffects. Using too much intensity can increase the risks, but using too little intensity for the clinical situation can lead to poor images and the loss of essential information.

When we use ultrasonic devices, we should remember the safety concerns. Ultrasound should neither be used as a "toy" or without clinical need, nor should it be considered "perfectly safe." We know and have known for more than 75 years that ultrasound, at certain levels, can alter biological systems. There will always be a need for continued awareness of future research findings. But we also know that one should not hesitate to have a diagnostic ultrasound examination when there is a clinical benefit to be derived.

Future benefit vs. risk

Q. In the future, might there be increased risk as well as increased benefit?

A. The future may be quite different. If existing acoustic output limits were removed, the primary responsibility for the safety of acoustic output would shift from design restrictions, as on current diagnostic ultrasound devices, to the judgement of the users. In return for potentially enhanced diagnostic capabilities, we will have to balance the clinical need against the risk of an adverse bioeffect. We will need a knowledge of the thermal and mechanical mechanisms, the bioeffects of ultrasound, the ultrasound output levels being used, and the relationship of output level to image quality.

Chapter Five

ALARA

Issues Addressed

- The ALARA principle
- Controlling ultrasonic energy
- Controlling exposure time
- System capability and ALARA
- Operating mode and ALARA
- Transducer capability and ALARA
- System setup and ALARA
- Scanning technique and ALARA

Q. Knowing that ultrasound energy is related to potential bioeffects, how can we reduce the risks?

ALARA, or As Low As Reasonably Achievable

A. We have a simple principle that we can apply to the use of ultrasound energy. It's called ALARA, which stands for "As Low As Reasonably Achievable." Following the ALARA principle means that we keep total ultrasound exposure as low as reasonably achievable, while optimizing diagnostic information.

With new ultrasound equipment, the output display lets us determine the exposure level in terms of the potential for bioeffects. For equipment that does not have an output display, we depend on whatever output information, such as intensity, dB, or percentage of power that the system provides.

Users control the total exposure to the patient.

Because the threshold for diagnostic ultrasound bioeffects is undetermined, it becomes our responsibility to control the total output exposure to the patient. Controlling the total exposure depends on output level and exposure time. The output level required for an exam depends on the patient and the clinical need. Not all diagnostic exams can be performed at very low levels. In fact, using too low a level may result in poor data and the need to repeat the examination. Using too high a level may not increase the quality of the information, but it will expose the patient to unneeded ultrasound energy.

What determines exposure time?

Q. If output level depends on the patient and the clinical need, what determines exposure time?

A. Ultimately, the exposure time depends on the person conducting the exam. Primarily, it's our training, education, and experience that determine how quickly we can obtain a useful image, and thus, the length of the exam and the amount of exposure. So, the question is, "How much time do we need to obtain the desired diagnostic information?"

System Capabilities:
Operating mode
Transducer capabilities
System setup
Scanning techniques
Knowledge and experience

But there are also some other factors that might affect the length of time that any particular tissue is exposed. One is the mode, whether it's a moving or stationary beam; and another is the choice of transducer. Other factors include the patient's body characteristics, the operator's understanding of the controls on the system and how they affect output levels, and whether it's continuous wave or pulsed Doppler, or color flow Doppler. To achieve ALARA, we need a thorough knowledge of the imaging mode, transducer capabilities, system setup, and operator scanning techniques.

Operating mode:
B-mode
M-mode
Doppler
Color flow Doppler

System capabilities include the following: mode, transducer capabilities, system setup, and scanning techniques. Let's talk about each. First, the mode we select, such as M-mode, B-mode, or Doppler, depends on what we're looking for. B-mode imaging gives anatomical information while Doppler and color flow Doppler modes give information about blood flow through vessels. M-mode gives information about how anatomical structures move in time.

Transducer capabilities:
Frequency
Penetration
Resolution
Field of View

Second, transducer capabilities relate to penetration at the frequency chosen, resolution, and the field of view that we can obtain with the selected transducer.

System setup:
Starting output power
Starting intensity outputs
Scanning results

Third, system setup and control settings depend on where we start on the output scale and on our knowledge of which combinations of controls gets the best results.

Scanning techniques:
Anatomy and pathology
Ultrasound physics
Signal processing features
Recording and playback features

Fourth, the scanning technique we use is based on out knowledge of anatomy and pathology, of ultrasound physics, and of the equipment's signal processing features, plus out experience with a given scanning modality, such as sector, linear, and so forth. A system's recording and playback features let use reduce exposure time to just the time necessary to obtain a useful image. Analysis and diagnosis can be performed using recorded images rather than lengthy live imaging sessions.

ALARA is a simple concept and easy to understand. Implementing ALARA well, however, requires all of out knowledge and skills as diagnostic ultrasound users. In Part Three we will learn how many of the controls found on diagnostic ultrasound equipment can affect ultrasound output. Without an output display standard we must rely on that knowledge to estimate a patient's ultrasound exposure. With an output display standard we have a real-time indication of the exposure in terms of the potential for bioeffects. Either way, we implement ALARA by minimizing the exposure level and duration while being sure to obtain the necessary diagnostic information.

Part Three

Implementing ALARA

Chapter Six

Knobology

Issues Addressed

- Basis of knobology
- Tradeoff between *in situ intensity* and image depth
- Operator controls and ALARA
- Prudent use
- Know the user's guide
- An example of implementing ALARA

Q. What should we know about equipment control features, "knobology," to implement ALARA?

A. Whether or not a diagnostic ultrasound system has an output display, the same types of controls are used to obtain the needed diagnostic images. We should understand how these controls affect acoustic output levels so we can use them to get the best image with the least exposure. In this chapter, we will learn about types of controls that are available on most ultrasound imaging equipment.

Operator controls and ALARA

Q. How can the operator control ultrasound output?

A. There are several external system controls the operator can adjust to improve the quality of the image and to minimize the output intensity. To understand how these controls are related to ALARA, let's divide them into three broad categories" First, controls that directly affect intensity. Second, controls that indirectly affect intensity. These are controls such as Mode, Pulse Repetition Frequency, and others. When you change the setting for one of these controls, you may also be changing the intensity. Third, controls that do not affect intensity. We can think of the third category as "receiver controls." There are controls that affect the processing of ultrasonic echoes returned from the body.

These aren't "official" categories, but they help us understand how the knobs affect ALARA. In fact, each equipment manufacturer provides somewhat different sets of controls.

Controls directly affecting intensity
Application selection
Output intensity

By reviewing the user's guide for the equipment, we can determine the particular controls that perform the functions described here.

Let's look at controls that affect intensity. They are application selection and output intensity.

Application selection

With application selection, we may choose from applications such as peripheral vessel, cardiac, ophthalmic, fetal imaging, and others. There may be different "ranges" of intensity output based on these applications. Selecting the right application range is the first thing you can do. For example, cardiac intensity levels are not generally recommended for performing a fetal scan. Some systems automatically select the proper range for a particular application, while others require a manual selection.

For equipment that does not have an output display, the maximum intensity for each application is regulated by the FDA. The FDA regulation is meant to limit ultrasonic output levels to ranges historically used for each application. But users have some choice in the matter; we are responsible for the proper selection of an application range.

For equipment with an output display, FDA currently regulates only the maximum output for the system. Manufacturers establish intensity ranges appropriate for typical patient examinations. However, within the system limits, users may override the application specific limits. We are responsible for being aware of the output level that is being used. We know the output level from the system's real-time output display.

Output intensity or power

Another control that has a direct effect on intensity is, of course, output intensity. This control also may be called transmit, power, or output. Once the appropriate application range has been selected, the transmit intensity control increases or decreases the output intensity within the range. Most equipment allows you to select intensity levels less than maximum, say 25 or 50 percent. ALARA implies that you select the lowest output intensity that is consistent with good image quality.

Q. Which controls indirectly affect intensity?

Controls indirectly affecting intensity:
System mode
Pulse repetition frequency
Focusing depth
Pulse length
Transducer choice

A. The second group of controls is intended to change aspects of the transmitted ultrasonic field other than the intensity. However, because they change the field, the intensity is affected. Whether the intensity increases or decreases and by how much is difficult to predict.

System mode

The choice of B-mode, or Doppler, for example, determines whether or not the ultrasound beam is stationary or in motion, which greatly affects the energy absorbed by the tissue. If the beam is moving, then each targeted tissue volume experiences the beam only for a fraction of the time, except near the transducer for sector scans. If the beam is stationary, then the period of time a targeted tissue volume in the beam receives ultrasound is increased.

Q. What about the pulse repetition frequency – PRF?

Pulse repetition frequency (PRF)

A. The number of ultrasound pulses in one second is referred to as the pulse repetition frequency. The higher the pulse repetition frequency, the more output pulses per second, increasing the temporal average intensity. There are several controls which have an effect on the pulse repetition frequency. For example, with some diagnostic ultrasound systems, if we decrease the focal range, then the system may automatically increase the PRF.

Focusing depth

Q. Nest on the list is focusing. How would focusing affect intensity?

A. In focusing, the beam is narrowed in order to get a better lateral resolution, increasing the temporal average intensity. Most systems adjust their output to offset the effects of focusing, so they tend to maintain the same intensities. As an operator, we need to set the transducer focus at the depth of the structure we're examining. Different exams require different focal depths. Setting the transducer focus at the proper depth improves the resolution of that structure, and we don't need to increase intensity to see it better.

Pulse length

Q. What about pulse length?

Pulse length, sometimes called burst length or pulse duration, is the time the pulse is on. Often the longer the pulse, the greater the temporal-average intensity value, which both raises the temperature in the tissue and slightly increase the likelihood for cavitation. In pulsed Doppler, increasing the Doppler sample volume length usually increases the pulse length.

Transducer choice

Q. Transducer choice is another factor that indirectly affects intensity. How?

A. Tissue attenuation increases with transducer frequency. The higher the frequency, the higher the attenuation. That is, a higher-frequency transducer requires more output intensity to ‘see’ at a greater depth. In order to scan deeper at the same output intensity, a lower transducer frequency must be used. So, for deeper structures, is we find ourselves maximizing output and gain without obtaining good image quality, we may have to switch to a lower frequency.

Receiver Controls that affect the image only
Receiver gain
TGC
Video dynamic range
Post processing

Q. We are calling the third category Receiver Controls. We use these to improve image quality. They have no effect on output; they only affect how the ultrasound echo is received and processed. The controls include gain, TGC, video dynamic range, and post processing. Let’s just look at one of these... system gain. How can we use receiver gain to implement ALARA?

Always increase the receiver gain first.

A. The receiver gain controls amplification of the return echo signal. To obtain good diagnostic information, we need a high return signal amplitude. This can be attained either by higher output, similar to talking louder, or by higher receiver gain, similar to a hearing aid with volume control. The need for gain is determined by tissue attenuation, that is, how much of the ultrasound is lost as it passes to the reflective surface and back to the transducer. In some cases, we control the receiver gain by setting the gain control or TGC. But in other cases, gain is automatically adjusted by the system when the user adjusts the output control. If the equipment has a receiver gain control, and we are searching for a weak signal, we should always increase the system’s receiver gain first, then increase the power output. That way, we reduce the output required and make it less likely to use

high acoustic intensities in the patient's body tissue. Remember, a low receiver gain may necessitate using a higher output, or result in suboptimal image quality.

Q. What is an example of ALARA in a clinical exam?

A. Imagine we are getting ready to do a liver scan. It will involve the use of B-mode, color, and Doppler.

Let's see how we would follow the ALARA principle to set up and conduct the exam.

Select transducer
Check output transmit setting
Adjust focus
Increase receiver gain
Adjust output transmit again

The first thing we need to do is select the appropriate transducer frequency. Next, we adjust the output intensity (or power) transmit setting. We check to make sure it is positioned at the lowest possible setting to produce an image. We adjust the focus to the area of interest, then increase the receiver gain to produce a uniform representation of the tissue. If we can obtain a good image by increasing the gain, we can lower the output and continue to increase the gain. Only after making these adjustments and if tissue penetration or echo amplitude levels are inadequate should we increase the output to the next higher level.

Minimize exposure time

After we have achieved a good B-mode image, then we can use color to localize the blood flow so we can position the Doppler sample volume. This allows us to locate the vessel of interest faster and that minimizes exposure time. Now that we have an image of the vessel, we position the range gate (or sample volume gate) over the vessel.

Adjust output transmit setting again

Now we can check the Doppler trace. We adjust the power setting by setting the Doppler transmit intensity at the lowest possible level to produce a clear signal. We will make a few more adjustments, for example, adjusting the velocity scale. Now we increase the receiver gain to get a diagnostic signal. If maximum gain adjustments are inadequate, then we raise the output to the next higher level.

That basically is how we implement ALARA. Select the right transducer, start with a low output level, and obtain the best image possible by focusing, receiver gain, and other imaging controls. If that is not adequate for diagnostic purposes, then increase the output level.

We can further implement ALARA by reducing total ultrasonic exposure time. That is, using our skill, experience, and knowledge of the patient, we can structure the exam to find and obtain useful images quickly. Recording and playing back parts or all of the exam for later measurement and analysis can further minimize the duration of the exposure.

Different systems have different controls and displays.

Q. There are many different types of ultrasound systems with different controls and displays. Does ALARA change from system to system?

Some systems do not have an output control.

A. ALARA remains the same. Keep ultrasound output “As Low As Reasonably Achievable.” How we do that will change somewhat from system to system. For example, virtually all medical diagnostic ultrasound equipment has some type of acoustic output control. However, we may occasionally see a single purpose device that doesn’t have an output adjustment. In this case, we practice ALARA by minimizing exposure time.

If the machine has an output control, we use it and the other controls to achieve ALARA. But remember, there are a variety of different types of intensity settings on ultrasound equipment, depending on the manufacturer’s design. For example, some equipment may have a separate control on the keyboard or console that has discrete increments. Other equipment may have the intensity level adjustment accessed through the system presets. And, output setting may be displayed in a variety of different ways. For example, acoustic output may be expressed as a percentage of total power, in decibels, in intensity units of milliwatts per square centimeter, or in thermal or mechanical indices.

In addition to the technical aspect of ALARA, there’s the philosophical aspect. This includes minimizing scan time, performing only required scans, and never compromising quality by rushing through an examination.

Acoustic output control:
percentage
decibel (dB)
Direct unit
(mW/cm2 or mW)
Thermal index
Mechanical index

Q. We're responsible for patient care, and we must use diagnostic ultrasound prudently. What's the rule for prudent use?

A. We want the best diagnostic information with minimal exposure to the patient. And because the threshold at which ultrasound energy causes bioeffects is not known, our goal must b to adjust the intensity output of the equipment so as to get the most information at the lowest possible output level.

That's what we mean by ALARA. Using settings that are "As Low As Reasonably Achievable" allow for the best quality ultrasound data for diagnosis.

Chapter Seven

The Output Display Standard

Issues Addressed

- Purpose of the Output Display Standard
- Mechanical Index (MI)
- Thermal Index (TI)
- Soft Tissue Thermal Index (TIS)
- Cranial Bone Thermal Index (TIC)
- Bone Thermal Index (TIB)
- When an Index is displays
- When the Indices mean
- How to implement ALARA by using the Indices

Q. What is the output display standard?

A. One of the many advances now being made in ultrasound equipment technology is the introduction of output display indices that relate to the potential for ultrasound bioeffects. These indices are specified in a standard developed in a cooperative effort by the National Electrical Manufacturers Association, the U.S. Food and Drug Administration, the American Institute of Ultrasound in Medicine, and many other medical and basic science societies.

Q. What is displayed?

Output Display
• Thermal Index (TI)
• Mechanical Index (MI)

A. Two types of indices may be displayed: a Thermal Index, or TI, which provides an estimate of the temperature increase; and a Mechanical Index, or MI, which provides an indication of the potential of nonthermal or mechanical bioeffects, such as cavitation.

Q. What is the purpose of the output display standard?

A. The goal of the output display standard is to make users aware of the actual output of their ultrasound equipment as it is being used. The TI and MI provide real-time information about the potential for bioeffects that can be used to help implement ALARA easily and efficiently. As users, we can quickly learn how different control settings change the indices. *We implement ALARA by obtaining needed information while keeping the indices, the potential for bioeffects, "as low as reasonably achievable."*

MI is a relative indicator of the potential for mechanical effects

Q. What is the Mechanical Index?

A. Scientific evidence suggests that mechanical, or nonthermal, bioeffects, like cavitation, are a threshold phenomenon, occurring only when a certain level of output is exceeded. However, the threshold level varies, depending on the tissue. The potential for mechanical effects is thought to increase as peak pressure increases, but to decrease as the ultrasound frequency increases. The Mechanical Index automatically accounts for both pressure and frequency. When interpreting the Mechanical Index, remember that it is intended to estimate the potential for mechanical bioeffects. The higher the index reading, the larger the potential. However, neither MI=1, nor any other level, indicates that a bioeffects is actually occurring. We should not be alarmed by the reading, but we should use it to implement the ALARA principle.

	Scanned Mode	Unscanned Mode
Soft Tissue	TIS at Surface	TIS Small Aperture Large Aperture
Bone at Focus	TIS at Surface	TIB
Bone at Surface	TIC	TIC

Q. What is the Thermal Index?

A. Actually, there are three Thermal Indices that are used for different combinations of soft tissue and bone in the area to be examined. The purpose of the Thermal Indices is to keep us aware of conditions that may lead to a temperature rise whether at the surface, within the tissues, or at the point where the ultrasound is focusing on bone. Each Thermal Index estimates temperature rise under certain assumptions.

Three Thermal Indices
• Soft Tissue Thermal Index (TIS)
• Cranial Bone Thermal Index (TIC)
• Bone Thermal Index (TIB)

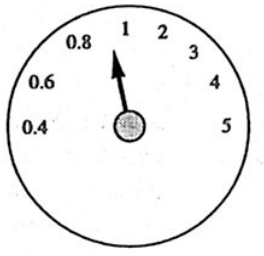
The Soft Tissue Thermal Index, known as TIS, provides information on temperature increase within soft homogeneous tissue. The Cranial Bone Thermal Index, called TIC, indicates temperature increase of bone at or near the surface, such as may occur during a cranial exam. The Bone Thermal, Index, or TIB, provides information on temperature increase of bone at or near the focus after the beam has passed through soft tissue. For example, TIB is appropriate when focusing near fetal bone during a second or third trimester exam.

TI is a relative indicator of temperature increase

The Thermal Index is a relative indicator of temperature rise. Thus, a TI reading of 2 represents a higher temperature rise than a TI reading of 1. However, a TI of 1 should not be taken literally to mean an actual increase of 1ºC, nor should a TI of 2 be taken to mean an increase of 2ºC. The actual increase in temperature in the patient is influences by a number of factors such as tissue type, blood perfusion, mode of operation, and exposure time. Those who developed the standard deliberately chose the term “Index” to avoid a literal association between the TI reading and actual temperature increase. The TI does, however, provide important information to the user: it indicated that the possibility for an increase in temperature exists, and it provides a relative magnitude that can be used to implement ALARA.

No display of any index value is required if the transducer and system are not capable of exceeding an MI or TI of 1.

Q. How and when are the output indices displayed?



A display of an index value as low as 0.4 is required if the transducer and system are capable of exceeding an MI or TI of 1.

A. The output display must be located so as to be easily seen by the operator during an exam. An output display is not required if the transducer and system are not capable of exceeding an MI or TI of 1. However, if the transducer and system are capable of exceeding and MI or TI of 1, then it must display values as low as .4 to help the user implement ALARA.

The standard only requires that a single index be displayed at any one time. For some modes and application presets the user may be able to choose which index shall be displayed. For example, the Mechanical Index will appear for B-mode imaging if no other mode is active. A Thermal Index will be shown for all other modes, including modes where B-mode imaging is combined with something else such as M-mode, Doppler, or color flow imaging. The standard makes an exception for

transducers that have no B-mode imaging. In that case, the Mechanical Index must be available in the Doppler mode.

The Mechanical Index is required for B-mode imaging because the mechanical effects, such as cavitation, are more likely to be significant than thermal effects. Similarly the rationale for using a Thermal Index in the other modes is that the potential for heating is the greater concern.

Q. Are there other system features required by the output display standard?

Manufacturers are required to provide default settings

A. The output display standard requires manufacturers to provide default settings on their equipment. These settings establish the output level that will be used automatically at power-up, entry of new patient information, and a change from nonfetal to fetal application presets. Once the exam is under way, the user should adjust the output level as needed to achieve clinically adequate images while keeping the output index as low as possible.

Q. Is it really that simple? All we need to know is the output index value?

A. Yes and no. A high index value does not always mean high risk, nor does it mean that bioeffects are actually occurring. There may be modifying factors which the index cannot take into account. But, high readings should always be taken seriously. Attempts should be made to reduce index values but not to the point that diagnostic quality is reduced.

Minimizing exposure time will help reduce risk

The indices do not take *time* into account. Exposure time is an important factor users must keep in mid, especially id the index is in a range that might be considered high. Exposure time is the ultrasound exposure time at a particular tissue region. In all cases, minimizing ultrasound exposure time will help reduce risk.

Every patient is different. The tissue characteristics assumed in the formulas for the output display indices may differ

significantly from the characteristics of the patient or exam type. Important characteristics we should consider include

- body size
- blood flow (or perfusion)
- the distance the organ of interest is from the surface
- where the bone is in relation to the beam axis and focal point, and
- factors, such as the presence or absence of fluid, that affects the attenuation of ultrasound.

Q. Tell us in more detail how to used the output display to help implement ALARA.

A. Let's look at the basic principles to follow. To begin, we determine if we are displaying the appropriate index. The Mechanical Index and Thermal Index are mode-specific, so that index selection is automatic. However, there may be cases when we can override the system's choice. When displaying a Thermal Index, we should ask four questions.

- Thermal IndexTissuesTypical Examinations
- TISSoft tissueCardiac, first trimester fetal
- TIBBone near focusSecond and third trimester fetal
- TICBone near surfaceTranscranial

First, "Which Thermal Index is appropriate for the study we are performing – TIS, TIC, or TIB?" TIS is appropriate when imaging soft tissue and is used, for example, during first trimester fetal exams or in cardiac color flow imaging exams. TIC is used during transcranial examinations. And TIB is used during second and third trimester fetal exams or certain neonatal cephalic exams.

The second question to as is, "Are there modifying factors that might create either an artificially high or low reading?" These modifying factors include the location of fluid or bone and blood flow. For example, is there a low attenuation path so that the actual potential for local heating is greater than the TI display? This could be caused by an unusually long distance of amnioti, or other fluid through which the ultrasound must travel. Another example is that a highly perfused tissue area may have a lower temperature than indicated because blood flow transports heat away from the tissue.

Third, even if the index value is low, we should ask, “Can I bring it down?” Because there is uncertainty about how high is “too high,” we should always be alert to ways to adjust the system to reduce the indices. In many cases, an index reading can be reduced without decreasing the quality of the image.

Finally, we should ask, “How can we minimize ultrasound exposure time without compromising diagnostic quality?” This does not mean that we rush through the exam and take the chance of not getting information necessary for an accurate diagnosis. It means that we should get the best image possible with as little exposure time as necessary. There are a number of ways to reduce exposure time. For example, if the system does not disable pulsing during freeze frame, remover the transducer from the patient while working with a frozen image on the ultrasound display. Don’t scan obstetrical patients twice, once to obtain necessary diagnostic information and again to show images to the patient’s family and friends. Only scan area of the body that are necessary to the diagnosis. And don’t use additional modes, such as Doppler or color, unless they benefit the diagnosis.

Q. Please give us some examples that show how the indices can be used to implement ALARA.

A. We will look at several examples. When we consider the Mechanical Index, the MI might be reduced by selection of appropriate transducer type, ultrasonic frequency, focal zone, and receiver gain.

Implementation of ALARA by using the indices

Because there are three Thermal Indices, it is not so simple. As we go through the examples, remember the four questions we should ask related to the Thermal Index:

- Which TI?
- Are there modifying factors?
- Can we reduce the index value?
- Can we reduce the exposure time?

The first example is a color flow scan of the portal vein of the liver. TIS is the appropriate selection for nonobstetrical abdominal examinations. Possible modifying factors include capillary perfusion and body size. High perfusion in the imaged tissue will reduce thermal effects while conversely, a lack of perfusion may increase them. With increasing body size, extra

tissue attenuation decreases mechanical and thermal effects at the focus. Also, when considering the focus for a soft tissue exam, remember that the potential for maximum heating might occur at the surface, at the focal point, or somewhere in between. For scanned modes, such as B-mode imaging and color flow, and for sector transducers, the maximum heating is usually close to the surface.

The second example is a pulsed Doppler cardiac system. Again, TIS is the appropriate thermal index. The cooling effect of cardiac blood flow is a very important modifying factor. Actual increase in cardiac temperature is almost certainly less than the TIS indicates.

The next example is a second trimester pulsed Doppler fetal exam. In most cases with unscanned modes, like pulsed Doppler, the Thermal Index indicates heating near the surface. If bone is not present, maximum heating is likely to occur between the surface and the focus or sample volume, and the TIS is the relevant index. But, if bone is present, maximum heating will occur at the location of the bone. In this example, the TIB is the relevant index, although it will overestimate the actual temperature rise, unless the bone is located within the focal zone or sample volume.

The presence of fetal bone near the focal zone is the important factor. If the pulsed Doppler is used to measure umbilical blood flow, and we are sure there is no bone near the sample volume, the TIS is appropriate. However, because the transducer may be moved, it is usually best to make the more conservative choice and select TIB for all second and third trimester exams. Of direct concern are the fetus's developing neural tissues, such as the brain and spinal cord, that may be in a region of heated bone.

Other modifying factors include the type of overlying tissue, whether fluid or soft tissue, and the exposure time at the particular tissue region. The presence of fluid is important, because if more than half of the path is fluid-filled then the actual temperature rise may be higher than the TIB value displayed. To reduce the potential temperature rise, consider aiming the transducer to miss most of the bone structure without losing the region of interest, if possible, and optimize receiver gain and sample volume controls.

An additional consideration is whether heating is likely to be near the surface (in the mother's tissues) or deeper (in the fetal tissues). This depends mostly on whether we are using a scanned (2D or color) or unscanned (M-Mode or Doppler) mode, For scanned modes, heating tends to be near the surface; for unscanned modes, closer to the focal zone. However, in most cases where bone is along the beam axis, maximum heating occurs at the location of the bone.

Another example is a transcranial examination, where TIC is the appropriate Thermal Index. The presence of bone near the surface is the important factor in this case. To reduce the TIC reading, consider scanning through a thinner part of the skull, so that a lower output setting can be used.

The final example is a neonatal cephalic exam. The choice of Thermal Index depends on the location of bone. Generally, in an exam through the fontanelle TIB is the appropriate index because of the chance of focusing near the base of the skull. TIS might be appropriate if the focal zones will always be above the base of the skull. If the exam is through the temporal lobe, the temporal bone near the surface make the TIC the appropriate index.

Conclusion

In more than three decades of use, there has been no report of injury to patients or to operators from medical ultrasound equipment. We in the ultrasound community want to keep that level of safety.

In the past, application-specific output limits and the user's knowledge of equipment controls and patient body characteristics have been the means of minimizing exposure. Now, more information is available. The Mechanical and Thermal Indices provide users with information that can be specifically applied to ALARA. Mechanical and Thermal Indices values eliminate some of the guesswork and provide both as indication of what may actually be happening within the patient and what occurs when control settings are changed. These make it possible for the user to get the best image possible while following the ALARA principle and, thus, to maximize the benefits/risk ratio.

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