

Evaluation of Doppler Ultrasound Velocity and Flow Measurements

by

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Abstract

Doppler ultrasound instruments have been used clinically for about 30 years and have proved to be highly reliable for the detection of arterial disease. In addition, a number of different Doppler instrument designs and techniques have been proposed to provide quantitative measurements such as volume blood flow, percent stenosis, and waveform indices.

We chose a two-pronged approach to the problem of evaluating Doppler ultrasound measurements of blood flow. We first developed a flow system that mimics the vasculature. The flow system comprises a computer-controlled pump, blood mimic, and a wall-less vessel phantom. A computer-controlled pump allows the production of accurate constant flow as well as pulsatile flow waveforms. The wall-less vessel phantom eliminates the artefacts introduced by the high attenuation and impedance mismatches of common vessel mimics such as latex rubber tubing.

Using this flow system, we evaluated the automated peak-frequency tracing algorithm used on an ATL HDI Doppler instrument. Values of diagnostic indices, including maximum systolic, minimum diastolic, time-averaged peak-frequencies, and pulsatility and resistance indices, measured by the automated routine were found to agree to within 4.5% of those measured manually.

The second approach was to develop a phantom which uses an acoustic beam splitter to combine separate clutter and flow sources to form the Doppler signal. The clutter component was provided by a moving belt. The flow component was provided either by a second belt (dual-belt phantom) or by a vascular phantom (belt/vascular phantom). The acoustic beam splitter split the ultrasonic beam so that the same Doppler sample volume was located within the clutter belt and flow source.

Using this phantom we evaluated the effects of the clutter belt velocity, flow belt velocity, and clutter-to-flow power ratio on the reported colour Doppler shifts. The results will show that the choice of wall filter, as well as the amplitudes and velocities of the clutter and flow components, affect the measured Doppler shift. Results obtained with the belt/vascular phantom show

that colour Doppler shifts due to the moving fluid depend strongly on the clutter belt velocity and choice of wall filter. However, only a small dependence on Doppler signal strength was observed.

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Table of Contents

certificate of examination.....	ii
abstract.....	iii
dedication.....	v
acknowledgements.....	vi
table of contents.....	viii
list of tables.....	xii
list of figures.....	xiii
Chapter 1 - introduction	1
1.1 Historical Review of Ultrasound.....	1
1.2 Ultrasonic B-mode Imaging.....	3
1.3 Doppler Ultrasound.....	5
1.3.1 Pulsed (Spectral) Doppler.....	7
1.3.2 Colour Doppler.....	9
1.4 Quantitative Doppler techniques.....	10
1.4.1 Velocity measurements.....	10
1.4.2 Spectral Doppler waveform measurements.....	10
1.4.3 Volume blood flow measurements.....	12
1.4.4 Other techniques.....	12
1.5 Thesis motivation.....	13
1.5.1 Fast flow.....	13
1.5.2 Slow flow.....	14
1.5.3 Waveform indices.....	15
1.6 Limitations of Doppler instruments.....	15
1.6.1 Velocity measurement accuracy.....	15
1.6.2 Spectral waveform analysis.....	16
1.6.3 Clutter and wall filters.....	17
1.6.4 Doppler sensitivity.....	19
1.7 Existing Doppler Evaluation Techniques.....	19
1.7.1 Vascular phantoms.....	20
1.7.2 Sensitivity phantoms.....	21
1.7.3 Mechanical phantoms.....	22
1.8 Overview of thesis.....	23

1.8.1 Chapter 2: Flow System.....	23
1.8.2 Chapter 3: Automated peak-frequency tracing algorithm..	23
1.8.3 Chapter 4: Clutter phantom.....	24
Chapter 2 - A Flow System For Doppler Ultrasound Studies.....	25
2.1 Flow system description.....	25
2.1.1 Vascular phantom.....	25
2.1.2 Tissue mimic.....	26
2.1.3 Blood mimic.....	27
2.1.4 Flow pump.....	27
2.2 Methods.....	29
2.2.1 Tissue mimic characterisation.....	29
2.2.2 Latex rubber characterisation.....	30
2.2.3 Blood mimic characterisation.....	30
2.2.4 Pump characterisation.....	31
2.2.5 Phantom measurements.....	32
2.2.6 Beam profile measurements.....	32
2.2.7 Computer model of Doppler amplitude spectra.....	33
2.3 Results.....	39
2.3.1 Tissue mimic characterisation.....	39
2.3.2 Latex rubber characterisation.....	46
2.3.3 Blood mimic characterisation.....	46
2.3.4 Pump characterisation.....	51
2.3.5 Phantom measurements.....	54
2.3.6 Ultrasound beam profile.....	56
2.3.7 Computer model of amplitude spectra.....	59
Appendix A1 Blood Mimic Characterisation Techniques.....	63
A1.1 Methods.....	63
A1.2 Acoustic velocity measurements.....	65
A1.3 Acoustic attenuation measurements.....	67
Chapter 3 - Evaluation of an Automated Real-Time Spectral Analysis Technique.....	70
3.1 Introduction.....	70
3.2 Automated peak-frequency tracing algorithm.....	70

3.3 Methods.....	75
3.3.1 Flow system.....	75
3.3.2 Effect of signal-to-noise ratio.....	75
3.3.3 Precision.....	76
3.3.4 Automated vs. manual tracing techniques.....	77
3.4 Results.....	77
3.4.1 Effect of signal-to-noise ratio.....	77
3.4.2 Precision.....	78
3.4.3 Automated vs. manual measurements.....	79
 Chapter 4: A Doppler Ultrasound Clutter Phantom.....	 92
4.1 Chapter overview.....	92
4.2 Clutter and sensitivity phantom designs.....	92
4.2.1 Dual belt phantom.....	92
4.2.2 Belt/vascular phantom	93
4.3 Methods.....	96
4.3.1 Operation.....	96
4.3.2 <i>In vivo</i> Doppler signal.....	96
4.3.3 Phantom characterisation.....	97
4.3.3.1 Belt velocity accuracy.....	97
4.3.3.2 Dual belt Doppler signal.....	98
4.3.3.3 Beam splitter linearity.....	98
4.3.3.4 Beam splitter distortion.....	98
4.3.3.5 Belt/vascular Doppler signal	99
4.3.3.6 Belt/vascular Doppler spectrum	99
4.3.4 Doppler evaluation: dual-belt phantom.....	99
4.3.4.1 Fixed clutter-to-flow power ratio	99
4.3.4.2 Varying clutter-to-flow power ratio.....	100
4.3.5 Doppler evaluation: belt/vascular phantom.....	101
4.3.5.1 Fixed clutter-to-flow power ratio.....	101
4.3.5.2 Varying transmit power.....	101
4.4 Results.....	102
4.4.1 <i>In-vivo</i> Doppler signal.....	102
4.4.2 Phantom characterisation.....	103
4.4.2.1 Belt velocity accuracy.....	103

4.4.2.2 Belt Doppler signal.....	103
4.4.2.3 Beam splitter linearity.....	103
4.4.2.4 Beam splitter distortion.....	104
4.4.2.5 Belt/vascular Doppler signal.....	104
4.4.2.6 Belt/vascular Doppler spectrum.....	104
4.4.3 Doppler evaluation: dual-belt phantom.....	105
4.4.3.1 Fixed clutter-to-flow power ratio.....	105
4.4.3.2 Varying clutter-to-flow power ratio.....	107
4.4.4 Doppler evaluation: belt/vascular phantom.....	108
4.4.4.1 Fixed clutter-to-flow power ratio.....	108
4.4.4.2 Varying transmit power.....	109
Appendix A2: Clutter Phantom Angles.....	135
Chapter 5: Discussion and Conclusions.....	136
5.1 Overview of thesis.....	136
5.1.1 Flow system for Doppler ultrasound studies.....	136
5.1.2 Evaluation of an automated real-time spectral analysis technique.....	140
5.1.3 Clutter phantom.....	142
5.2 Future work.....	146
5.2.1 Flow system.....	146
5.2.2 Automated waveform analysis.....	147
5.2.3 Clutter phantom.....	149
References.....	152
vita.....	164

List of Tables

Table	
2.1	Coefficients obtained by fitting Equation 2.1 to the curves plotted in Figures 2.3 and 2.4.....40
2.2	Table of coefficients used in Equation 2.11 to approximate the experimental beam profiles.....59
2.3	First moments of computed Doppler spectra for different vessels insonated by an ultrasound beam.....60
2.4	First moments of computed Doppler spectra for small radius vessels insonated by an ultrasound beam.....61
3.1	System parameters used for the precision and automated vs. manual comparison studies.....77
3.2	Results of various waveform parameters obtained from using the automated peak-frequency tracing algorithm.....79
3.3	Standard deviations in waveform parameters due to between- and within-observer variations, and Doppler speckle and electronic noise.....83

List of Figures

Figure	
1.1	B-mode image of a common carotid artery and jugular vein.....5
1.2	B-mode image showing sample volume location.....7
1.3	Spectral display of a common carotid artery waveform.....8
1.4	Colour Doppler image of a common carotid artery.....9
1.5	Graph of RI measurements from renal arteries.....16
1.6	Image showing a computer simulation of an ultrasonic pulse....18
2.1	Schematic and photograph of a wall-less vessel phantom.....27
2.2	Schematic of computer-controlled pump.....28
2.3	Coordinate systems used to describe the vessel and the ultrasound beam.....34
2.4	Schematic showing the cross section of the vessel.....35
2.5	Schematic showing how the acoustic attenuation is determined by the tissue, vessel wall, and blood.....37
2.6	Graphs showing the received signal amplitude, calculated using Equation 2.10.....39
2.7	Graphs showing the acoustic attenuation coefficient plotted as a function of frequency for agar gels (50 μm cellulose).....41
2.8	Graphs showing the acoustic attenuation coefficient plotted as a function of frequency for agar gels (20 μm cellulose).....42
2.9	Plot showing the acoustic attenuation coefficients for various tissues plotted as a function of frequency.....43
2.10	Plot showing the effects of glycerol, in a 3% agar gel, on the attenuation coefficients of a 5.7 MHz ultrasound pulse.....44
2.11	Plot showing the effect of Sigmacell, in a 3% agar gel, on the acoustic velocity.....45
2.12	Plot showing the effect of glycerol, in a 3% agar gel, on the acoustic velocity.....45
2.13	Plot showing the attenuation coefficient for latex rubber tubing plotted as a function of frequency.....46
2.14	Plots showing the attenuation coefficients vs. frequency for various haematocrits of Orgasol 3501 and Orgasol 2001.....48
2.15	Graph showing the attenuation coefficients vs. frequency for

	various concentrations of machine cutting fluid and water.....	49
2.16	Plot showing the acoustic velocity vs. haematocrit for two types of Orgasol.....	49
2.17	Plot showing the dependence of the acoustic velocity on the concentration of machine cutting fluid in water.....	50
2.18	Plot showing the dependence of the viscosity on the concentration of machine cutting fluid in water.....	50
2.19	Optical microscope image of Orgasol 2001 EXD Nat 1 in a 50% mixture of Syn-Cut HD and distilled water.....	51
2.20	Graph showing the pressure generated by the pump.....	52
2.21	Graphs showing the linearity and accuracy of steady flow.....	53
2.22	Graph showing the haemolysis resulting from operating the pump at a constant flow rate of 20 mL/s.....	54
2.23	B-mode images of vascular phantoms.....	55
2.24	Graph showing amplitude spectra obtained from the three different vascular phantoms.....	56
2.25	Graphs showing the linear array beam profiles.....	57
2.26	Linear array multiple beam profiles.....	58
2.27	Graph showing results of the computer model.....	62
A1.1	Schematic of the apparatus used to measure the acoustic velocity and attenuation of the blood mimic.....	64
A1.2	Schematic of the electronics used to measure the acoustic velocity and attenuation of the blood mimic.....	65
A1.3	Graph showing the transit time of an ultrasonic pulse as a function of the linear stage position.....	67
A1.4	Graph showing the relative transmitted ultrasound power as a function of the linear stage position.....	69
3.1	Schematic diagram of an hypothetical spectrum.....	73
3.2	Spectral displays of simulated renal waveforms.....	74
3.3	Graph showing the five grey-scale curves that map the spectral amplitude to displayed intensity.....	76
3.4	Doppler spectra, using grey-scale curve 1, of constant flow of 5 mL/s for five signal-to-noise-ratios.....	84
3.5	Graphs showing time-average peak frequency measurements of constant flow plotted as a function of SNR.....	85

3.6	Graphs showing the dependence on SNR of various waveform parameters.....	86
3.7	Graph showing the average fractional differences between the automated and manual measurements.....	88
3.8	Graphs showing the between-observer variations for the manual tracing technique normalised by the overall means.....	89
3.9	Graphs showing the variations in the two tracing techniques manual tracing technique normalised by the overall means.....	91
4.1	Diagram and photograph of the Dual Belt phantom.....	94
4.2	Diagram and photograph of the Belt/vascular phantom.....	95
4.3	Graphs showing the pre-wall filtered Doppler signal amplitude from a common carotid artery plotted as a function of time.....	111
4.4	Plot of the Fourier transform of Doppler data from Figure 4.3a	112
4.5	Spectral Doppler images of the pre-wall filtered Doppler signal obtained from a common carotid artery.....	113
4.6	Spectral display of the pre-wall filtered data shown in Figure 4.5, with amplitude displayed on a logarithmic scale....	114
4.7	Spectral display of the data shown in Figure 4.5, except that a 100 Hz wall-filtered has been applied.....	115
4.8	Plots showing the conversion between programmed motor speed and belt velocity and velocity linearity of the phantom..	116
4.9	Graphs showing the pre-wall filtered Doppler signal amplitude from the dual-belt phantom.....	117
4.10	Spectral Doppler image of the pre-wall filtered data shown in Figure 4.9.....	118
4.11	Spectrum obtained with the flow and clutter belts moving at 24.1 cm/s and 12.3 cm/s respectively.....	119
4.12	Plots showing Doppler amplitude spectra acquired with Doppler angles of 67° and 74°.....	120
4.13	Graphs showing the pre-wall filtered Doppler signal amplitude from the belt/vascular phantom.....	121
4.14	Doppler amplitude spectra acquired from an 0.24 cm diameter wall-less vessel phantom and clutter belt.....	123
4.15	Graphs showing the average colour Doppler shift plotted as a function of the clutter belt velocity.....	124

4.16	Two-dimensional plots showing the average colour Doppler shift coded as a colour plotted as a function of clutter belt velocity and flow belt velocity.....	126
4.17	Graphs showing the average colour Doppler shift plotted as a function of the ratio of clutter-to-flow power.....	127
4.18	Two-dimensional plots showing the average colour Doppler shift coded as a colour plotted as a function of clutter belt velocity and clutter-to-flow power ratio.....	129
4.19	Graphs showing the average colour Doppler shift in an ROI centred on a 0.23 cm diameter vessel, plotted as a function of the clutter belt velocity.....	131
4.20	Two-dimensional graphs showing the colour Doppler shifts contained within an ROI centred on a 0.23 cm diameter vessel, plotted as a function of the clutter belt velocity.....	132
4.21	Two-dimensional graphs showing the colour Doppler shifts contained within an ROI centred on a 0.16 cm diameter vessel, plotted as a function of output power.....	134
A2.1	Schematic showing angle of Doppler probe, beam splitter and flow belt with respect to the clutter belt.....	135
5.1	Drawing showing an alternative configuration of the phantom that uses two wall-less phantoms.....	150