

*A comparison of echocardiography,  
thoracic impedance and beat to beat  
blood pressure for biventricular  
pacemaker optimisation*

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# Introduction

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- 3927 BIVs implanted in the UK in 2007<sup>1</sup>
- Only a fraction of patients undergo optimisation
- Reasons for low numbers
  - Lack of randomised trial evidence
  - Reliability of optimisation procedures
  - Time consuming

# Current evidence base for optimisation

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## – AV optimisation:

- Sawhney et al, Randomized prospective trial of atrioventricular delay programming for cardiac resynchronization therapy. Heart Rhythm 2004;1:562.

## – VV optimisation:

- Boriani et al. Randomized comparison of simultaneous biventricular stimulation versus optimized interventricular delay in cardiac resynchronization therapy: The Resynchronization for the Hemodynamic Treatment for Heart Failure Management II implantable cardioverter defibrillator (RHYTHM II ICD) study. American Heart Journal 2006;151:1050.

# Optimisation techniques

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- Echocardiography
- Invasive LV  $dP/dt$
- Intracardiac electrograms
- Impedance cardiography
- Beat to beat BP
  
- Ideal technique
  - very reliable/reproducible
  - Intrinsic variability small compared with differences obtained between settings

# Echo

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- Variety of methods
  - LVOT VTI
  - CW VTI
  - Ritter's method

# Thoracic impedance

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- As a technique it has been around for decades
- Stroke volume estimated by assessing changes in resistance in the thoracic cavity
- Significant concerns raised about accuracy of cardiac output results
- BIV optimisation not necessarily interested in absolute values – but single patient variations

# Thoracic impedance

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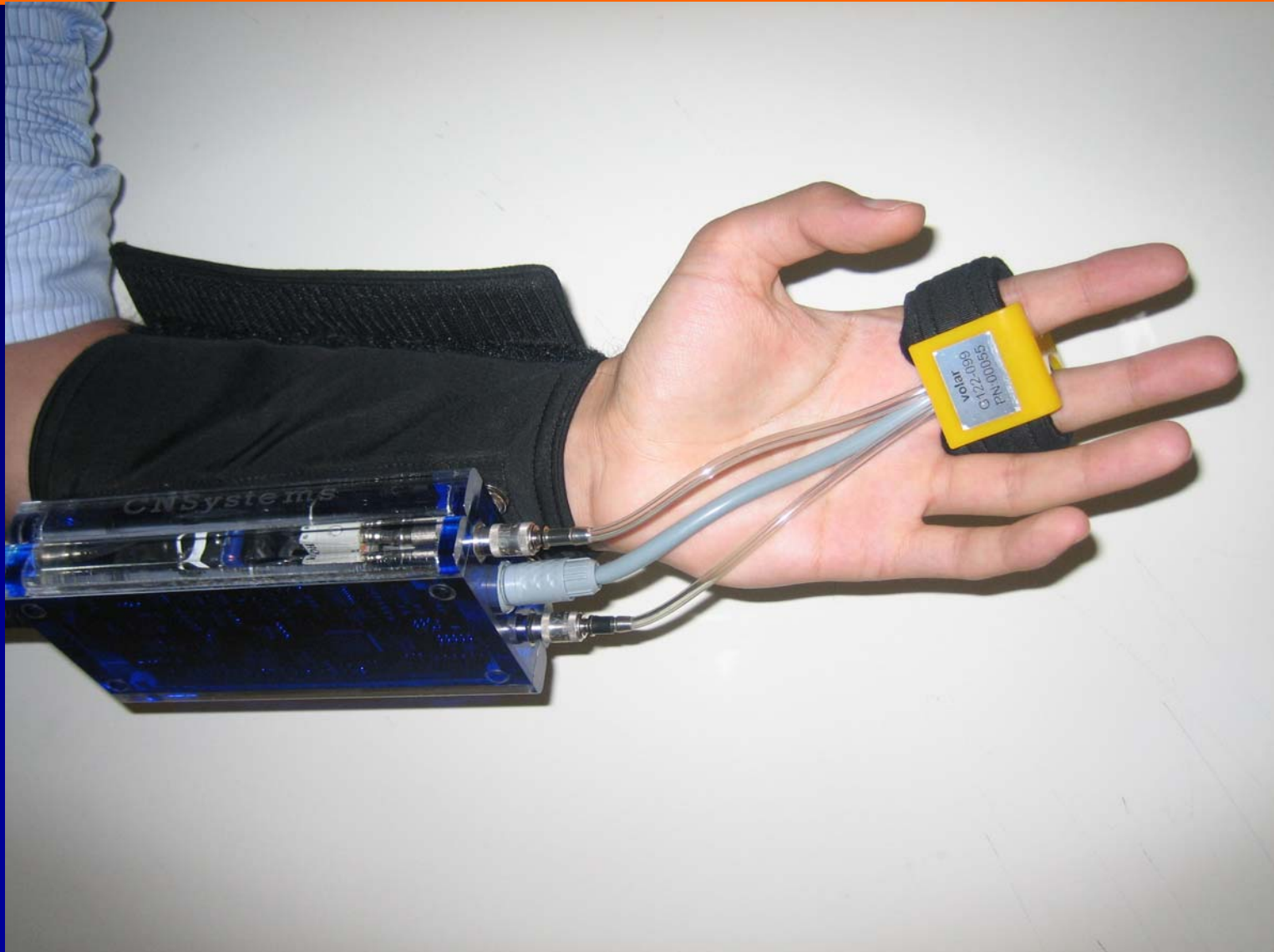


# Beat to beat BP

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- Monitoring using a finger cuff and the vascular unloading technique pioneered by Penaz 33 years ago
- Mostly widely known device is the Finometer
- St Mary's have published widely using Finometer

# Beat to beat BP



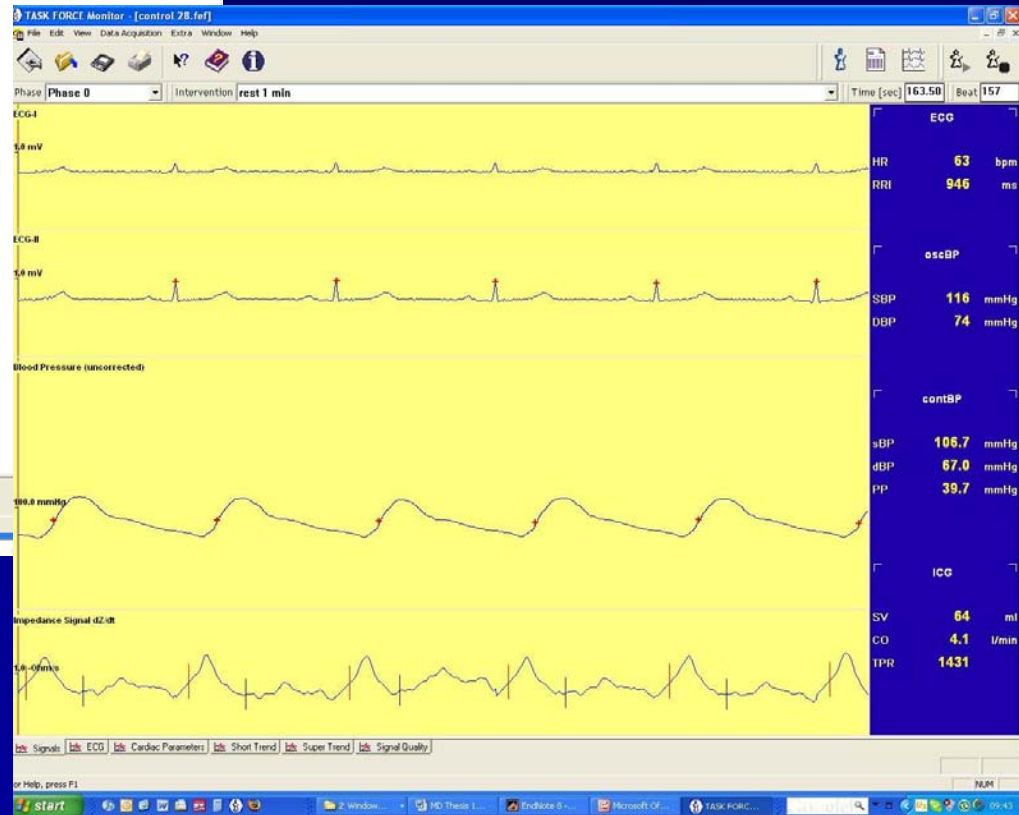
# Task Force Monitor Output

TASK FORCE Monitor [control 28.fcf]

Phase **Phase 0** Intervention **rest 1 min** Time [sec] **163.50** Beat **157**

Description	HR	sBP	dBP	mBP	PP	CO	CI	SV	SI	IC	ACI	dP/dt	TPRI	LVWt	LVET	PEP
	[bpm]	[mmHg]	[mmHg]	[mmHg]	[mmHg]	[l/min]	[l/(min <sup>2</sup> )]	[ml]	[ml/beat]	[l/1000/s]	[100/]	[mmHg/s]	[dbeat <sup>2</sup> /min <sup>2</sup> /cm <sup>2</sup> s]	[mmHg <sup>2</sup> /min/s <sup>2</sup> ]	[ms]	[ms]
rest 1 min	65.4	113.4	73.4	82.1	40.1	4.1	2.3	63	35.4	33.7	29.5	33.6	2754	2.5	316	65
Mean	65.4	113.4	73.4	82.1	40.1	4.1	2.3	63	35.4	33.7	29.5	33.6	2754	2.5	316	65
rest 1 min 2	60.0	100.0	67.4	76.2	40.6	4.1	2.3	67	37.4	35.9	32.1	33.0	2606	2.3	304	65
Mean	60.0	100.0	67.4	76.2	40.6	4.1	2.3	67	37.4	35.9	32.1	33.0	2606	2.3	304	65
rest 1	80.5	134.8	82.5	101.4	42.3	4.1	2.3	83	38.5	33.5	27.5	33.7	3611	3.1	312	85
Mean	80.5	134.8	82.5	101.4	42.3	4.1	2.3	83	38.5	33.5	27.5	33.7	3611	3.1	312	85
rest 2	56.8	127.4	86.9	96.6	40.5	3.6	2.0	63	35.3	33.2	28.1	33.6	3743	2.6	330	83
Mean	56.8	127.4	86.9	96.6	40.5	3.6	2.0	63	35.3	33.2	28.1	33.6	3743	2.6	330	83
exercise	87.3	124.3	77.6	89.5	46.7	6.3	3.5	72	40.4	45.7	51.9	49.9	2005	4.2	287	70
Mean	87.3	124.3	77.6	89.5	46.7	6.3	3.5	72	40.4	45.7	51.9	49.9	2005	4.2	287	70
peak 1 min	100.2	128.6	82.2	94.9	48.3	6.5	3.7	85	38.6	42.8	62.3	56.4	2017	4.6	282	77
Mean	100.2	128.6	82.2	94.9	48.3	6.5	3.7	85	38.6	42.8	62.3	56.4	2017	4.6	282	77
peak 1 min 2	98.7	122.4	77.7	88.5	44.7	6.4	3.6	84	38.6	41.3	63.2	57.8	1963	4.2	282	81
Mean	98.7	122.4	77.7	88.5	44.7	6.4	3.6	84	38.6	41.3	63.2	57.8	1963	4.2	282	81
nl	99.1	123.8	75.4	89.6	48.4	6.6	3.7	87	37.4	44.2	58.2	60.3	1892	4.4	284	76
Mean	99.1	123.8	75.4	89.6	48.4	6.6	3.7	87	37.4	44.2	58.2	60.3	1892	4.4	284	76
peak 1 D	98.2	125.5	77.2	92.2	49.3	7.3	4.1	74	41.3	53.3	68.7	59.4	1765	5.0	259	73
Mean	98.2	125.5	77.2	92.2	49.3	7.3	4.1	74	41.3	53.3	68.7	59.4	1765	5.0	259	73
peak 1 U	84.8	123.8	72.8	88.1	51.0	6.7	3.7	77	42.8	48.2	56.6	61.5	1873	4.3	285	76
Mean	84.8	123.8	72.8	88.1	51.0	6.7	3.7	77	42.8	48.2	56.6	61.5	1873	4.3	285	76
peak 2 D	93.9	--	--	--	--	--	6.6	3.7	70	39.3	47.3	62.2	--	--	271	76
Mean	93.9	--	--	--	--	--	6.6	3.7	70	39.3	47.3	62.2	--	--	271	76
peak 2 U	83.7	--	--	--	--	6.4	3.6	76	42.5	47.4	50.3	--	--	--	296	76
Mean	83.7	--	--	--	--	6.4	3.6	76	42.5	47.4	50.3	--	--	--	296	76
nl	79.6	128.2	78.1	94.0	50.0	5.4	3.0	68	30.1	41.6	47.0	71.7	2101	4.2	292	91
Mean	79.6	128.2	78.1	94.0	50.0	5.4	3.0	68	30.1	41.6	47.0	71.7	2101	4.2	292	91

Intervention Log | OscBP | Real Mean | Cardiac Statistics | Cardiac Parameters



# Study aims

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- Repeatability of echo, thoracic impedance and BP techniques
- Maximal benefit of optimisation using echo, thoracic impedance and BP techniques

# Methods

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- 25 BIV subjects optimised at 80bpm.

AV	AV	AV	AV	Optimal	Optimal	Simult	LV	LV	RV
80	120	160	200	- 20	+ 20		20	40	20

- 30 secs delay after change prior to recordings
- 3 continuous beats of CW through AV
- 3 continuous beats of PW at LVOT
- 20 secs recording of BP and SV data

# Methods - Statistics

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- Maximal benefit of optimisation = the difference between the best and the worst AV and VV settings
- Repeatability of setting calculated

AV	AV	AV	AV	Optimal	Optimal	Simult	LV	LV	RV
80	120	160	200	- 20	+ 20		20	40	20

- Bland Altman technique
- Repeatability expressed as 2 standard deviations (coefficient of repeatability)

# Results

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	Repeatability	max benefit	
		AV	VV
<b>CW cm/s</b>	2.4	3.7	2.5
<b>PW cm/s</b>	3.4	2.5	5.0
<b>SBP mmHg</b>	14	14.8	9.2
<b>DBP mmHg</b>	10.6	10.2	6.4
<b>MBP mmHg</b>	11.4	12.0	7.1
<b>PP mmHg</b>	10.2	17.1	5.0
<b>SV mls</b>	6.1	11.2	5.0

# Conclusions

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- The haemodynamic benefit of AV optimisation was significantly larger than VV optimisation
- BP measures using out protocol were less repeatable than the other techniques
- Thoracic impedance has a similar ability to differentiate between optimal settings as echo
- Both techniques are likely to be poor at reliably differentiating between VV settings
- Thoracic impedance may provide a reliable, quick and simple alternative to echo for BIV optimisation

# Study limitations

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- Low sample size
- BP measurements not similar to St Mary's protocol and BP may drift across time
- Optimisation took place using a set pattern
  - AV then VV optimisation
- No clinical outcome data