Appendix A: Sources of evidence considered in the preparation of the overview

A Details of assessment report:

Lawinski C, Emerton D and Kazantzi M, KCARE. VeriQ system for assessment of graft flow during coronary artery bypass graft. May 2011.

B Submissions from the following manufacturer/sponsors:

MediStim ASA

C Related NICE guidance

Guidance on the prevention of cardiovascular disease at the population level. NICE public health guidance 25 (June 2010). Available from www.nice.org.uk/guidance/PH25

Endoscopic saphenous vein harvest for coronary artery bypass grafting. NICE interventional procedure guidance 343 (May 2010). Available from www.nice.org.uk/guidance/IPG343

Endovascular stent – grafts for the treatment of abdominal aortic aneurysms. NICE technology appraisal guidance 167 (February 2009). Available from www.nice.org.uk/guidance/TA167

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Appendix B: Comments from professional bodies

Expert advice was sought from experts who have been nominated or ratified by their Specialist Society, Royal College or Professional Body. The advice received is their individual opinion and does not represent the view of the society.

Professor Gianni Angelini
Clinical Chair of Cardiothoracic Surgery and Head of Cardiac Surgery, Society for Cardiothoracic Surgery, Great Britain and Ireland

Mr Simon Kendall
Consultant Cardiothoracic Surgeon, Society for Cardiothoracic Surgery, Great Britain and Ireland

Mr Stephen Large
Consultant in Cardiothoracic Surgery, Society for Cardiothoracic Surgery, Great Britain and Ireland

Mr Peter O'Keefe
Consultant Cardiothoracic Surgeon, Society for Cardiothoracic Surgery, Great Britain and Ireland

Mr Andre Simon
Director of Transplantation and Consultant Cardiac Surgeon, German Society of Thoracic and Cardiovascular Surgeons

Mr Ian Wilson
Consultant Cardiac Surgeon, Society for Cardiothoracic Surgery, Great Britain and Ireland

- Two advisers describe the technology as a minor variation on existing technologies; two think it is a significant modification and two describe it as a thoroughly novel technology.
- Comparators mentioned for CABG include SPY Indocyanine green fluorescence imaging, ultrasound as doppler velocity measurement,

electromagnetic flowmeters, the Transonic flowmeter and table angiography.

- Additional patient benefits through use of this technology include prompt re-do grafting if poor graft technique is demonstrated, improved quality assurance of graft patency, reduced risk of early graft failure and improved early and late mortality following CABG.
- Additional benefits for the healthcare system include better outcomes for patients and reduced unplanned secondary interventions. At present 10–15% grafts fail before hospital discharge so early identification of these problems with this technology has the potential to reduce hospital costs for these patients. One adviser was not convinced these are 'likely' benefits to the healthcare system.
- Five expert advisers who have experience of this device agree that users of this technology need proper training. Two advisers mention training, particularly in interpreting the results. Three advisers mention that the technology is straightforward to use.
- One adviser believes that use of the technology will result in overall significant reduction in costs. Two advisers mention cost as a barrier because of an expensive purchase price. One adviser mentions that if this technology is introduced there would be a major cost to the NHS.

Appendix C: Comments from patient organisations

The following patient organisations were contacted and no response was received.

- Arrhythmia Alliance
- Action against Medical Accidents (AvMA)
- Action Heart
- Atrial Fibrillation Association
- British Cardiac Patients Association
- British Heart Foundation
- British Liver Trust
- British Lung Foundation
- Cardiomyopathy Association
- Counsel and Care
- CritPaL – Patient Liaison Committee of the Intensive Care Society
- Grown up congenital heart patients association
- Heartcare Partnership UK
- ICU Steps
- National Heart Forum (UK)
- Royal College of Surgeons Patient Liaison Group
- The British Kidney Patient Association
- The Kidney Alliance
- Trauma Care
- The Vascular Society

Appendix D: Additional analyses

EXTERNAL ASSESSMENT CENTRE SUPPLEMENTARY REPORT

Title: VeriQ system for assessment of graft flow during coronary artery bypass graft; Economic review (EP119)

Produced by	*KCARE (EAC 331)*
Home unit	*King's College Hospital NHS Foundation Trust, London*
Authors	*Donald Emerton, Author.* *Chris Lawinski, Reviewer Consultant Physicist, KCARE.*
Contribution of Authors	*As a above*
Correspondence to	*Donald Emerton, KCARE, Department of Medical Engineering and Physics, King's College Hospital Denmark Hill, London, SE5 9RS.*
Date completed	*May 2011*

Declared interests of the authors

None

Acknowledgements

None

Rider on responsibility for report

The views expressed in this report are those of the authors and not necessarily those of the Centre for Health Technology Evaluation. Any errors are the responsibility of the authors.

CONTENTS

Abbreviations

CABG	Coronary Artery Bypass Graft
EAC	External Assessment Centre
IABP	Intra aortic balloon pump
KCARE	EAC 331
MI	Myocardial infarction
NICE	National Institute for Health and Clinical Excellence
TTFM	Transit Time Flow Measurement or Transit Time Flowmeter

1. Background

Additional economic analysis by the EAC was requested by NICE to examine the effects on cost effectiveness of the use of the three versions of the VeriQ system with the two cardiac TTFM probes.

There are three current versions of the VeriQ system, which each have different levels of functionality (Table 1). The original manufacturer's submission *de nova model* only considered the cost effectiveness of the VeriQ 2011 with the PS probe (for completeness the results from the manufacturer's (adjusted) base case has been included in this report).

Table 1. Number of functional channels and price of the various VeriQ systems

System	Flow	Doppler	Pressure	ECG/Aux.	Price
VeriQ 2011	2	none	1	1	£32,000
VeriQ 2111	2	1	1	1	£42,000
VeriQ 4122	4	1	2	2	£47,000

The three versions (Table 1, above) of the VeriQ which can be used for the assessment of CABG patency with either of two cardiac probes (Table 2, below). The system can be supplied with other TTFM probes for assessment of vessel other than coronary; these are not considered in this submission.

Table 2: Cardiac TTFM probe costs

Probe	Size range	No. of uses	Prices	Cost per treatment
PS	1.5 to 7 mm	30	£1582	£104.19*
PQ	1.5 to 5 mm	50	£1582	£68.33

Note: * this is taken from the adjusted manufacturer's base case.

It should be noted that for lager vessels the PS probe will be required.

The costs per patient scanned (Table 2) are based on the purchase cost of the VeriQ systems divided by 220 day per year use (one patient per day) over 10 years (life expectancy of equipment) plus the cost of the probe divided by number of uses, multiplied by the 1.7 probes used (average) per patient scanned.

2. Economic analysis

A summary of the relevant areas of the manufacturer's submission document for the cost analysis is shown in Table 3.

Table 3: Summary of key information for cost analysis

	Reference in submission document	Key tables/figures in submission document
Review of literature	p48 to 52	-
Model structure	p52	-
Transition probabilities	P55 to 64	-
Time horizon	p53	Table B9
Adverse events	p71	-
Resource use and costs	p8, p57 to 86	Table A1, Table B10, B14, B16
Sensitivity analysis	p76 to 86	-
Results	p72 to 86	-

EAC note: *Due to a typographic error in entering the labour costs for nurses into the Excel file, many of the figures throughout the manufacturer's submission are incorrect. It was also noted that the incorrect figures were used for the PS probe costs in the Excel spreadsheet. The PS probe costs set out in table A1 of the manufacturer's submission were not used to arrive at the average cost per treatment presented in this report; the probe cost of £1582 was used.*

Sensitivity analysis

The sensitivity analysis undertaken by the manufacturer considered the variables set out in Table 4. This table sets out the ranges and base case position for the manufacturer's cost analysis.

Table 4: Variables and ranges used in the sensitivity analysis

Parameter	Range	Base case
Duration of TTFM per procedure, mins	2 to 5	2.35
No of probes per procedure	1.4 to 2	1.7
Cost of probe per use, £	61.29 to 62.30	61.29
Probe uses	30 to 50	30
Rate of Patient with revisions, %	2.20 to 14.6	6.58
Duration minor revision, mins	2 to 5	2.5
Duration major revision, mins	27 to 57	42
Rate of minor revision, %	20 to 50	34.7

Cost of re-operative procedure, £	80 to 288	180.41
Re-operative procedure rate, %	0.6 to 8.5	3.0
Cost of deep sternal infection, £	687 to 1425	860.55
Deep sternal infection rate, %	0.0 to 5.5	1.0
IABP cost, £	1968 to 3346	2657.37
IABP rates, %	**0.0 to 13.9**	**1.0**
MI costs, £	1267 to 2067	1666.96
MI rates, %	**0.0 to 11.3**	**0.0**
Cost of CABG team per min, £	2.63 to 4.96	4.16

Note: the EAC is confident that these values realistically represent the best and worst case scenarios.

The variables which have the greatest effect on the cost effectiveness of the use of the VeriQ systems are the assumed rates for IABP and MI; the effect of these can be seen in the tables (B, D, F, H, J and M) in appendix 1 of this report. There is only one 'worst case' scenario (where the assumed rate of IABP is the same (3.5%) for both arms of the analysis) that shows the cost to the NHS to be greater than the benefit of using the VeriQ system, all other scenarios show a saving to the NHS.

Data sources

All data sources used by the manufacturer were reviewed by the EAC and were found acceptable.

Costs

Table 5. Cost per treatment

	PS probe	PQ probe
VeriQ 2011	£104.19*	£68.33
VeriQ 2111	£108.74	£72.88
VeriQ 4122	£111.01	£75.15

Note: * this scenario was presented in the original EAC assessment.

The probe costs from Table 5 were used to generate six base case analyses (Table 6), requested by NICE, against the use of clinical assessment.

Table 6. Summary of the base case analysis for the VeriQ systems and probes

	VeriQ 2011		VeriQ 2111		VeriQ 4122	
Probe used	**PS**	**PQ**	**PS**	**PQ**	**PS**	**PQ**
Graft assessment	£121.73	£85.87	£126.28	£90.42	£128.55	£92.69
Total cost per patient	£162.32	£126.46	£166.87	£131.01	£169.14	£133.28
Saving from VeriQ	£121.06	£156.92	£116.51	£152.37	£114.24	£150.10

Note: Full tables presented in appendix 1 of this report.

As can be seen, the 'base case' scenarios show that a saving to the NHS is made regardless of which probe or version of the VeriQ is used.

Table 7 shows the effect of the worst and best case scenarios taken from the manufacturer's submission and applied to the probe costs set out in table 5.

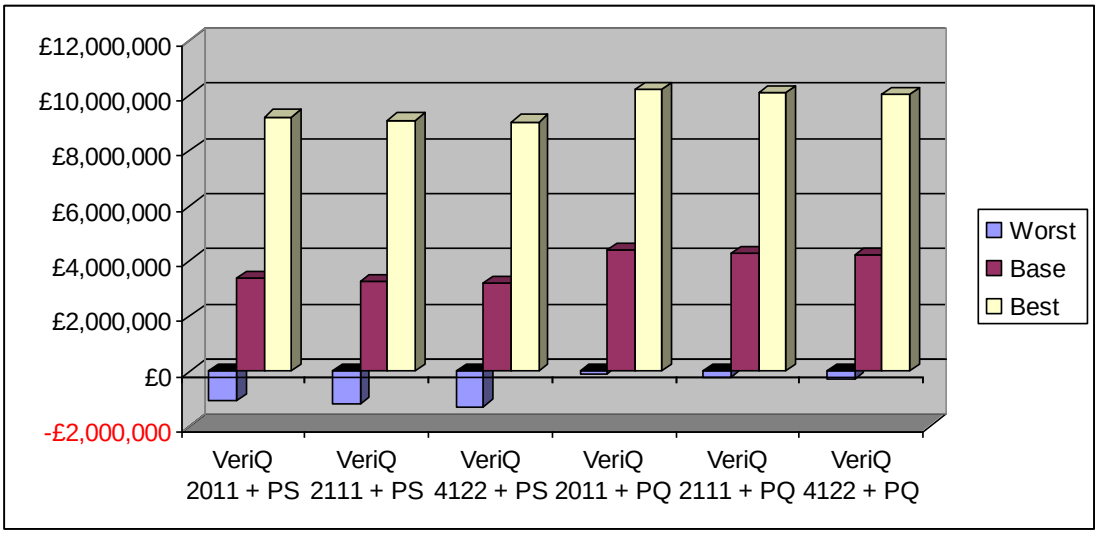
Table 7. Total savings to the NHS of using the VeriQ system

System used	Best Case	Base case	Worst Case
VeriQ 2011 + PS	£9,237,926	£3,389,595	-£1,074,780
VeriQ 2011 + PQ	£10,242,066	£4,393,675	-£70,700
VeriQ 2111 + PS	£9,110,526	£3,262,195	-£1,202,180
VeriQ 2111 + PQ	£10,114,606	£4,266,275	-£198,100
VeriQ 4122 + PS	£9,046,966	£3,198,635	-£1,265,740
VeriQ 4122 + PQ	£10,051,046	£4,202,715	-£261,660

Note: these are based on the base assumption.

The figures in Table 7 show the predicted savings (or cost) to the NHS if all 28,000 patients undergoing CABG per year were scanned intra-operatively using the VeriQ systems to assess patency of the grafts, Figure 1 shows this graphically.

Figure 1: Saving to the NHS if VeriQ system is used



It can be seen from Figure 1 that the 'worst case' costs to the NHS are far smaller than the predicted savings generated from the 'base case' analysis.

The 'base case' is considered to be the one closest to current reality within the NHS.

3. Servicing

The cost of servicing the equipment was not considered in the manufacturer's submission; Table 8 sets out the cost to the NHS per patient scanned if servicing is taken in to account. Servicing is payable from the end of year two at £1800 per year. It was assumed that the servicing for the eight years from year three to year 10 would be averaged over the 10 year life expectancy of the equipment, this results in the probe cost as set out in Table 8.

Table 8: Cost per use of probe with servicing included

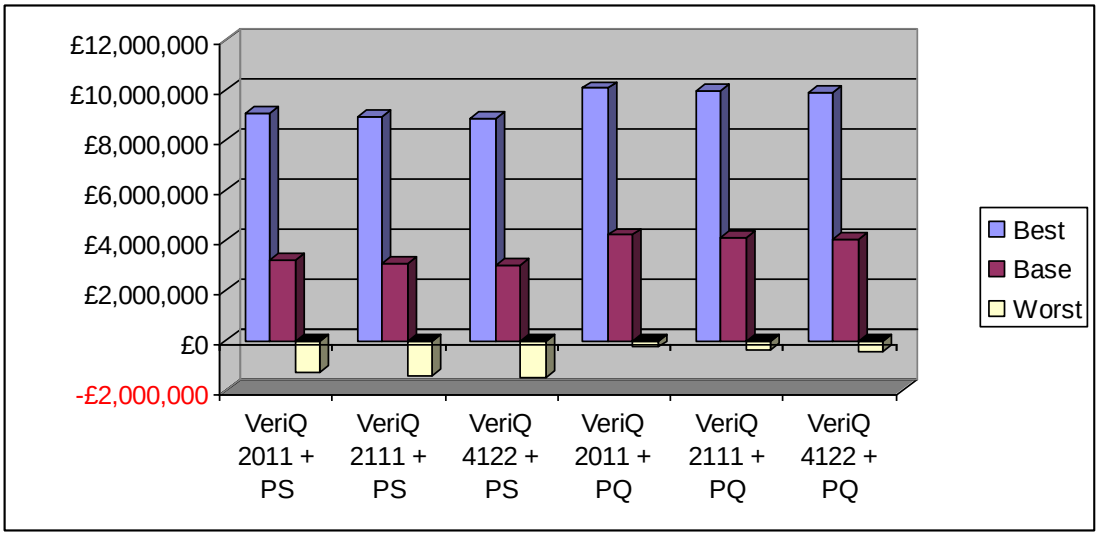
	VeriQ 2011		VeriQ 2111		VeriQ 4122	
Probe used	**PS**	**PQ**	**PS**	**PQ**	**PS**	**PQ**
Saving from VeriQ	£110.74	£74.88	£115.28	£79.42	£117.56	£81.70

With servicing included (probe costs from Table 8) the savings/cost to the NHS as a whole (assuming that all 28,000 patient undergoing CABG are scanned) are as shown in Table 9.

Table 9: Sensitivity analysis with service costs included

System used	Best	Base	Worst
VeriQ 2011 + PS	£9,054,526	£3,206,195	-£1,258,180
VeriQ 2011 + PQ	£10,058,606	£4,210,275	-£254,100
VeriQ 2111 + PS	£8,927,406	£3,079,075	-£1,385,300
VeriQ 2111 + PQ	£9,931,486	£4,083,155	-£381,220
VeriQ 4122 + PS	£8,863,566	£3,015,235	-£1,449,140
VeriQ 4122 + PQ	£9,867,646	£4,019,315	-£445,060

Figure 2: Savings to the NHS if servicing is included



Work load

The variations of cost effectiveness with workload were examined and it was found that the VeriQ system with the PQ probe made a saving to the NHS even in the worst case scenario (IABP rates with and without the use of TTFM are assumed to be the same) if the systems is used between seven and nine time per week, (seven - VeriQ 2011; eight -VeriQ 2111, nine - VeriQ 4122) or more. The PS probe never reaches a realistic point where the worst case scenario makes a saving.

The reason for the PS probe never realistically returning a saving in the worst case scenario is that the incremental costs of the probe are far larger than the contribution from the fixed costs (system purchase, etc.). However, the PS and PQ probes used with any of the three versions of the VeriQ system do show a saving in all base case analyses (Table 6).

However, if the VeriQ 2011 system is used once per week, in the base case scenario with the PS probe, the NHS will still save £30.25 per patient scanned and with the PQ probe will save £98.73 per patient scanned.

4. Conclusion

In all base case analyses the use of the VeriQ system is shown to make a saving for the NHS. The only scenario where the VeriQ system possibly does not make a saving is a the 'worst case' scenario where the occurrence of IABP is the same (3.5%) regardless of whether the VeriQ is used or not. It should be noted that in this scenario, a small change in these rates of less than 1.5% can show that the VeriQ system is always more cost effective than clinical assessment alone. In all other scenarios (best, base or worst case) the use of the VeriQ system to assess cardiac graft patency intra-operatively makes a saving to the NHS per patient scanned and therefore to the NHS as a whole.

From the economic evidence submitted by the manufacturer in the submission, the EAC considers that the use of the VeriQ system or other systems using similar technology may be beneficial to the NHS and should be considered for promotion by NICE

Appendix I:

Table A. VeriQ 2011 PS probe base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			104.19			0.00			104.19
Cost of TTFM use per patient			**113.98**			**0.00**			**113.98**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**121.73**			**0.00**			**121.73**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**162.32**		**283.38**	**-121.06**

Table B. VeriQ 2011 with PS probe sensitivity analysis

	Variable values					Delta Cost values, £			Width of interval
Variable	Best Case		Base Case	Worst Case					£
Duration of TTFM per procedure, min		2	2.35	5		-122.51	-121.06	-110.02	12.49
Mean No. of probes per procedure		1.4	1.7	2		-139.44	-121.06	-102.67	36.77
Rate of pats with revisions		2.20%	6.58%	14.60%		-126.22	-121.06	-111.61	14.61
Duration of minor revisions, min		2	2.5	5		-121.10	-121.06	-120.82	0.29
Duration of major revisions, min		27	42	57		-123.74	-121.06	-118.37	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-122.71	-121.06	-119.46	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-121.06	-121.06	-121.06	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-135.31	-121.06	-106.80	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-121.06	-121.06	-121.06	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-167.70	-121.06	-74.42	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-162.38	-121.06	-79.70	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-329.93	-121.06	38.38	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-141.06	-121.06	-101.06	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-225.74	-121.06	-44.00	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-127.51	-121.06	-117.72	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-121.12	-121.06	-121.00	0.12

Table C. VeriQ 211 PQ probe base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			68.33			0.00			68.33
Cost of TTFM use per patient			**78.12**			**0.00**			**78.12**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**85.87**			**0.00**			**85.87**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**126.46**		**283.38**	**-156.92**

Table D. VeriQ 2011 with PQ probe sensitivity analysis

	Variable values					Delta Cost values, £			Width of interval
Variable	Best Case		Base Case	Worst Case		Best	Base	Worst	£
Duration of TTFM per procedure, min		2	2.35	5		-158.37	-156.92	-145.88	12.49
Mean No. of probes per procedure		1.4	1.7	2		-168.98	-156.92	-144.86	24.12
Rate of pats with revisions		2.20%	6.58%	14.60%		-162.08	-156.92	-147.47	14.61
Duration of minor revisions, min		2	2.5	5		-156.96	-156.92	-156.68	0.29
Duration of major revisions, min		27	42	57		-159.60	-156.92	-154.23	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-158.57	-156.92	-155.32	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-156.92	-156.92	-156.92	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-171.17	-156.92	-142.66	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-156.92	-156.92	-156.92	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-203.56	-156.92	-110.28	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-198.24	-156.92	-115.56	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-365.79	-156.92	2.52	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-176.92	-156.92	-136.92	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-261.60	-156.92	-79.86	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-163.37	-156.92	-153.58	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-156.98	-156.92	-156.86	0.12

Table E. VeriQ 2111 PS probe base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			108.74			0.00			108.74
Cost of TTFM use per patient			**118.53**			**0.00**			**118.53**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**126.28**			**0.00**			**126.28**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**166.87**		**283.38**	**-116.51**

Table F. VeriQ 2111 with PS probe sensitivity analysis

	Variable values					Delta Cost values, £			Width of interval
Variable	Best Case		Base Case	Worst Case					£
Duration of TTFM per procedure, min		2	2.35	5		-117.96	-116.51	-105.47	12.49
Mean No. of probes per procedure		1.4	1.7	2		-135.70	-116.51	-97.32	38.38
Rate of pats with revisions		2.20%	6.58%	14.60%		-121.67	-116.51	-107.06	14.61
Duration of minor revisions, min		2	2.5	5		-116.55	-116.51	-116.27	0.29
Duration of major revisions, min		27	42	57		-119.19	-116.51	-113.82	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-118.16	-116.51	-114.91	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-116.51	-116.51	-116.51	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-130.76	-116.51	-102.25	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-116.51	-116.51	-116.51	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-163.15	-116.51	-69.87	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-157.83	-116.51	-75.15	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-325.38	-116.51	42.93	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-136.51	-116.51	-96.51	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-221.19	-116.51	-39.45	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-122.96	-116.51	-113.17	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-116.57	-116.51	-116.45	0.12

Table G. VeriQ 2111 PQ probe base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			72.88			0.00			72.88
Cost of TTFM use per patient			**82.67**			**0.00**			**82.67**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**90.42**			**0.00**			**90.42**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**131.01**		**283.38**	**-152.37**

Table H. VeriQ 2111 with PQ probe sensitivity analysis

	Variable values				Delta Cost values, £			Width of interval
Variable	Best Case	Base Case	Worst Case		Best	Base	Worst	£
Duration of TTFM per procedure, min	2	2.35	5		-153.82	-152.37	-141.33	12.49
Mean No. of probes per procedure	1.4	1.7	2		-165.23	-152.37	-139.51	25.72
Rate of pats with revisions	2.20%	6.58%	14.60%		-157.53	-152.37	-142.92	14.61
Duration of minor revisions, min	2	2.5	5		-152.41	-152.37	-152.13	0.29
Duration of major revisions, min	27	42	57		-155.05	-152.37	-149.68	5.37
Relative rate of minor revisions	50.0 %	34.7 %	20.0 %		-154.02	-152.37	-150.77	3.25
Re-operative procedures, cost (£)	288.00	180.41	80.00		-152.37	-152.37	-152.37	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-166.62	-152.37	-138.11	28.50
Deep sternal infection, cost (£)	1425.00	860.55	687.00		-152.37	-152.37	-152.37	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-199.01	-152.37	-105.73	93.28
IABP, cost (£)	3346.00	2657.37	1968.00		-193.69	-152.37	-111.01	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-361.24	-152.37	7.07	368.31
MI, costs (£)	2067.00	1666.96	1267.00		-172.37	-152.37	-132.37	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-257.05	-152.37	-75.31	181.74
Cost of CABG team composition, (£)	2.63	4.16	4.96		-158.82	-152.37	-149.03	9.79
On-pump rate	70.0 %	80.0 %	90.0 %		-152.43	-152.37	-152.31	0.12

Table I. VeriQ 4122 PS probe base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			111.01			0.00			111.01
Cost of TTFM use per patient			**120.80**			**0.00**			**120.80**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**128.55**			**0.00**			**128.55**
Consequences of not doing TTFM									
Intraoperative issues:									
Re-exploration of bleeding, rate	3.00%			3.00%			0.00%		

Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%		0.00%
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%		-6.00%
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%		-5.00%
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**169.14**		**283.38**	**-114.24**

Table J. VeriQ 4122 with PS probe sensitivity analysis

		Variable values							Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-115.69	-114.24	-103.20	12.49
Mean No. of probes per procedure		1.4	1.7	2		-133.83	-114.24	-94.65	39.18
Rate of pats with revisions		2.20%	6.58%	14.60%		-119.40	-114.24	-104.79	14.61
Duration of minor revisions, min		2	2.5	5		-114.28	-114.24	-114.00	0.29
Duration of major revisions, min		27	42	57		-116.92	-114.24	-111.55	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-115.89	-114.24	-112.64	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-114.24	-114.24	-114.24	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-128.49	-114.24	-99.98	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-114.24	-114.24	-114.24	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-160.88	-114.24	-67.60	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-155.56	-114.24	-72.88	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-323.11	-114.24	45.20	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-134.24	-114.24	-94.24	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-218.92	-114.24	-37.18	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-120.69	-114.24	-110.90	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-114.30	-114.24	-114.18	0.12

Table K. VeriQ 4122 PQ probe base case

Resource factor V3 2111 1582 50	CABG w/TTFM			CABG			Difference		
	Value	Unit	Cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			75.15			0.00			75.15
Cost of TTFM use per patient			**84.94**			**0.00**			**84.94**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**92.69**			**0.00**			**92.69**
Consequences of not doing TTFM									
Intraoperative issues:									
Re-exploration of bleeding, rate	3.00%			3.00%			0.00%		

Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%		0.00%
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%		-6.00%
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%		-5.00%
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**133.28**		**283.38**	**-150.10**

Table L. VeriQ 4122 with PQ probe sensitivity analysis

	Variable values					Delta Cost values, £			Width of interval
Variable	Best Case		Base Case	Worst Case		Best	Base	Worst	£
Duration of TTFM per procedure, min		2	2.35	5		-151.55	-150.10	-139.06	12.49
Mean No. of probes per procedure		1.4	1.7	2		-163.36	-150.10	-136.84	26.52
Rate of pats with revisions		2.20%	6.58%	14.60%		-155.26	-150.10	-140.65	14.61
Duration of minor revisions, min		2	2.5	5		-150.14	-150.10	-149.86	0.29
Duration of major revisions, min		27	42	57		-152.78	-150.10	-147.41	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-151.75	-150.10	-148.50	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-150.10	-150.10	-150.10	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-164.35	-150.10	-135.84	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-150.10	-150.10	-150.10	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-196.74	-150.10	-103.46	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-191.42	-150.10	-108.74	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-358.97	-150.10	9.34	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-170.10	-150.10	-130.10	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-254.78	-150.10	-73.04	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-156.55	-150.10	-146.76	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-150.16	-150.10	-150.04	0.12

EXTERNAL ASSESSMENT CENTRE SUPPLEMENTARY REPORT

Title: VeriQ system for assessment of graft flow during coronary artery bypass graft; Economic review, including service costs (EP119).

Produced by	*KCARE (EAC 331)*
Home unit	*King's College Hospital NHS Foundation Trust, London*
Authors	*Donald Emerton, Author* *Chris Lawinski, Consultant Physicist, KCARE*
Contribution of Authors	*Donald Emerton, Author* *Chris Lawinski, Reviewer*
Correspondence to	*Donald Emerton, KCARE, Department of Medical Engineering and Physics, King's College Hospital Denmark Hill, London, SE5 9RS*
Date completed	*June 2011*

Declared interests of the authors

None

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Rider on responsibility for report

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CONTENTS

Abbreviations

CABG	Coronary Artery Bypass Graft
EAC	External Assessment Centre
IABP	Intra aortic balloon pump
KCARE	EAC 331
MI	Myocardial infarction
NICE	National Institute for Health and Clinical Excellence
TTFM	Transit Time Flow Measurement or Transit Time Flowmeter

1. Background

NICE requested additional economic analysis to be undertaken by the EAC in order to examine the effects on cost effectiveness of the use of the three versions of the VeriQ system with the two cardiac TTFM probes including the cost of serving.

On the UK market the VeriQ is currently available in three versions, which have different levels of functionality (Table 1).

Table 1. Number of functional channels and price of the various VeriQ systems

System	Flow	Doppler	Pressure	ECG/Aux.	Price
VeriQ 2011	2	none	1	1	£32,000
VeriQ 2111	2	1	1	1	£42,000
VeriQ 4122	4	1	2	2	£47,000

The three versions of the VeriQ can all be used for the assessment of CABG patency with either of the two cardiac probes (Table 2,). Other TTFM probes are available for assessment of other vessels; these are not considered in this report.

Table 2. Cardiac TTFM probe costs

Probe	Size range	No. of uses	Prices	Cost of probe per use
PS	1.5 to 7 mm	30	£1582	£52.73
PQ	1.5 to 5 mm	50	£1582	£31.64

Note: the cost of sterilising the probes between uses has not been considered

The cost of the probe per use (Table 2) is simply the probe price divided by the predicted number of uses.

2. Analysis

Costs

The costs per patient scanned (Table 3) are based on the purchase cost of the VeriQ systems divided by 220 days per year use (one patient per day) over 10 years (life expectancy of equipment) including service costs. Service costs are payable from the end of year two at £1800 per annum. It is assumed that the service costs for the eight years (year 3 to 10) would be averaged over the 10 year life expectancy of the equipment. Added to this, in order to give the treatment cost per patient (as shown in table 3), is the cost of the

probe divided by number of uses multiplied by the 1.7 probes used (on average) per patient scanned.

Table 3. Cost per patient scanned including service costs

System	PS probe	PQ probe
VeriQ 2011	£110.74	£74.88
VeriQ 2111	£115.28	£79.42
VeriQ 4122	£117.56	£81.70

Note: it is assumed that 1.7 probes are used per patient

The costs per patient scanned (from Table 3) were used to generate six base case scenarios and related sensitivity analyses. A summary of these results are shown in table 4, savings (or costs) are against the use of clinical assessment alone.

Table 4. Summary of the base case analysis for the VeriQ systems and probes

	VeriQ 2011		VeriQ 2111		VeriQ 4122	
Probe used	**PS**	**PQ**	**PS**	**PQ**	**PS**	**PQ**
Graft assessment	£128.28	£92.42	£132.82	£96.96	£135.10	£99.24
Total cost per patient	£168.87	£133.01	£173.41	£137.55	£175.69	£139.83
Savings from use of VeriQ	£114.51	£150.37	£109.97	£145.83	£107.69	£143.55

Note: Full tables presented in appendix 1 of this report. Note: positive values indicate a saving to the NHS, negative values indicate a cost to the NHS

As can be seen Table 4, the ‘base case’ scenarios for all combinations of VeriQ system and probe show a saving to the NHS per patient scanned.

Table 5 shows the effect of the worst and best case scenarios taken from the manufacturer’s submission and applied to the probe costs (set out in table 3) for the NHS as a whole.

Table 5. Sensitivity analysis with service costs included for the NHS

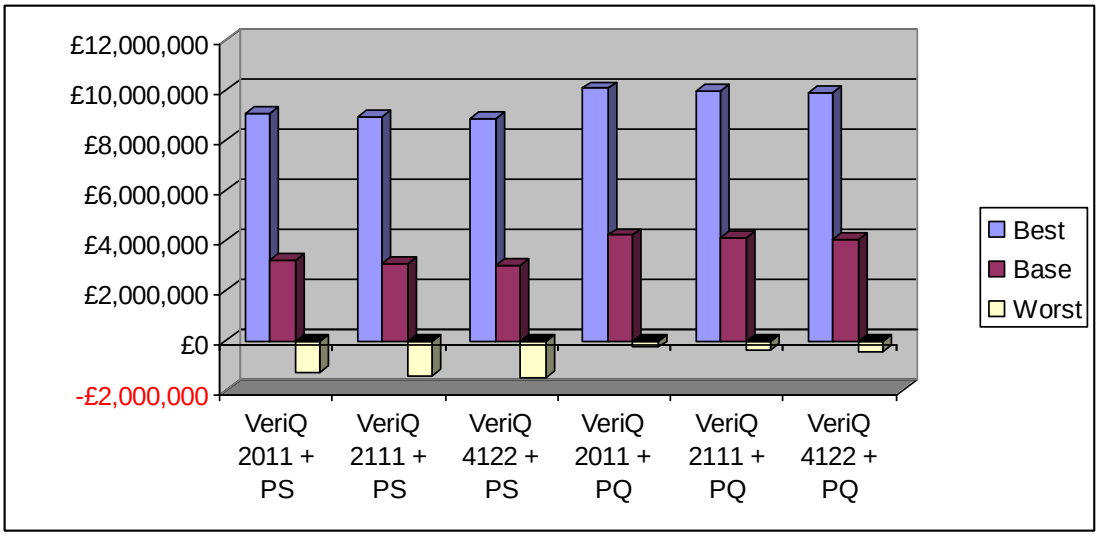
System used	Best	Base	Worst
VeriQ 2011 + PS	£9,054,526	£3,206,195	-£1,258,180
VeriQ 2011 + PQ	£10,058,606	£4,210,275	-£254,100
VeriQ 2111 + PS	£8,927,406	£3,079,075	-£1,385,300
VeriQ 2111 + PQ	£9,931,486	£4,083,155	-£381,220
VeriQ 4122 + PS	£8,863,566	£3,015,235	-£1,449,140
VeriQ 4122 + PQ	£9,867,646	£4,019,315	-£445,060

Note: positive values indicate a saving to the NHS, negative values indicate a cost to the NHS

The figures in Table 5 show the predicted savings (or costs) to the NHS if all 28,000 patients undergoing CABG per year were scanned intra-operatively using the VeriQ systems to assess patency of the grafts. Figure 1 shows this graphically.

The greatest possible saving of £10,058,606 to the NHS is the best case scenario using the VeriQ 2011 with the PQ probe and the highest cost to the NHS is £1,449,140 is from the worst case scenario where the VeriQ 4122 is used with the PS probe. As can be seen, all base case scenarios show a possible saving to the NHS of between £4,210,275 and £3,015,235 per annum.

Figure 1. Savings to the NHS including service costs



Note: positive values indicate a saving to the NHS, negative values indicate a cost to the NHS

3. Conclusions

In the base case analysis the use of any of the VeriQ systems with either probe is shown to make a saving to the NHS. The worst case scenarios where the VeriQ systems do not make a saving are where the occurrence of intra aortic balloon pump (IABP) rates are the same (3.5%) regardless of whether the VeriQ is used or not (clinical assessment alone). A small change in these rates of less than 2% can show that the VeriQ system is always more cost effective than clinical assessment alone, resulting in a saving to the NHS. In all other scenarios (best, base or worst case) the use of any of the VeriQ system/probe combinations to assess cardiac graft patency intra-operatively

makes a saving to the NHS per patient scanned and therefore to the NHS as a whole.

From the economic evidence submitted by the manufacturer in the submission, the EAC considers that the use of the VeriQ system or other systems using similar technology may be beneficial to the NHS and should be considered for promotion by NICE.

Appendix I:

Table A. VeriQ 2011 PS probe and service costs - base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			110.74			0.00			110.74
Cost of TTFM use per patient			**120.53**			**0.00**			**120.53**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**128.28**			**0.00**			**128.28**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**168.87**		**283.38**	**-114.51**

Table B. VeriQ 2011 with PS probe and service costs - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-115.96	-114.51	-103.47	12.49
Mean No. of probes per procedure		1.4	1.7	2		-134.05	-114.51	-94.96	39.08
Rate of pats with revisions		2.20%	6.58%	14.60%		-119.67	-114.51	-105.06	14.61
Duration of minor revisions, min		2	2.5	5		-114.55	-114.51	-114.27	0.29
Duration of major revisions, min		27	42	57		-117.19	-114.51	-111.82	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-116.16	-114.51	-112.91	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-114.51	-114.51	-114.51	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-128.76	-114.51	-100.25	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-114.51	-114.51	-114.51	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-161.15	-114.51	-67.87	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-155.83	-114.51	-73.15	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-323.38	-114.51	44.93	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-134.51	-114.51	-94.51	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-219.19	-114.51	-37.45	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-120.96	-114.51	-111.17	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-114.57	-114.51	-114.45	0.12

Table C. VeriQ 2011 PQ probe and service costs - base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			74.88			0.00			74.88
Cost of TTFM use per patient			**84.67**			**0.00**			**84.67**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**92.42**			**0.00**			**92.42**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**133.01**		**283.38**	**-150.37**

Table D. VeriQ 2011 with PQ probe and service costs - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-151.82	-150.37	-139.33	12.49
Mean No. of probes per procedure		1.4	1.7	2		-163.58	-150.37	-137.15	26.43
Rate of pats with revisions		2.20%	6.58%	14.60%		-155.53	-150.37	-140.92	14.61
Duration of minor revisions, min		2	2.5	5		-150.41	-150.37	-150.13	0.29
Duration of major revisions, min		27	42	57		-153.05	-150.37	-147.68	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-152.02	-150.37	-148.77	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-150.37	-150.37	-150.37	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-164.62	-150.37	-136.11	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-150.37	-150.37	-150.37	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-197.01	-150.37	-103.73	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-191.69	-150.37	-109.01	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-359.24	-150.37	9.07	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-170.37	-150.37	-130.37	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-255.05	-150.37	-73.31	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-156.82	-150.37	-147.03	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-150.43	-150.37	-150.31	0.12

Table E. VeriQ 2111 with PS probe and service costs - base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			115.28			0.00			115.28
Cost of TTFM use per patient			**125.07**			**0.00**			**125.07**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**132.82**			**0.00**			**132.82**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**173.41**		**283.38**	**-109.97**

Table F. VeriQ 2111 with PS probe and servicing - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-111.42	-109.97	-98.93	12.49
Mean No. of probes per procedure		1.4	1.7	2		-130.31	-109.97	-89.62	40.69
Rate of pats with revisions		2.20%	6.58%	14.60%		-115.13	-109.97	-100.52	14.61
Duration of minor revisions, min		2	2.5	5		-110.01	-109.97	-109.73	0.29
Duration of major revisions, min		27	42	57		-112.65	-109.97	-107.28	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-111.62	-109.97	-108.37	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-109.97	-109.97	-109.97	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-124.22	-109.97	-95.71	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-109.97	-109.97	-109.97	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-156.61	-109.97	-63.33	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-151.29	-109.97	-68.61	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-318.84	-109.97	49.47	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-129.97	-109.97	-89.97	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-214.65	-109.97	-32.91	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-116.42	-109.97	-106.63	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-110.03	-109.97	-109.91	0.12

Table G. VeriQ 2111 with PQ probe and service costs - base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			79.42			0.00			79.42
Cost of TTFM use per patient			**89.21**			**0.00**			**89.21**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**96.96**			**0.00**			**96.96**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**137.55**		**283.38**	**-145.83**

Table H. VeriQ 2111 with PQ probe and service costs - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-147.28	-145.83	-134.79	12.49
Mean No. of probes per procedure		1.4	1.7	2		-159.84	-145.83	-131.81	28.03
Rate of pats with revisions		2.20%	6.58%	14.60%		-150.99	-145.83	-136.38	14.61
Duration of minor revisions, min		2	2.5	5		-145.87	-145.83	-145.59	0.29
Duration of major revisions, min		27	42	57		-148.51	-145.83	-143.14	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-147.48	-145.83	-144.23	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-145.83	-145.83	-145.83	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-160.08	-145.83	-131.57	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-145.83	-145.83	-145.83	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-192.47	-145.83	-99.19	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-187.15	-145.83	-104.47	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-354.70	-145.83	13.61	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-165.83	-145.83	-125.83	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-250.51	-145.83	-68.77	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-152.28	-145.83	-142.49	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-145.89	-145.83	-145.77	0.12

Table I. VeriQ 4122 PS probe and service costs - base case.

Resource factor	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			117.56			0.00			117.56
Cost of TTFM use per patient			**127.35**			**0.00**			**127.35**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**135.10**			**0.00**			**135.10**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**175.69**		**283.38**	**-107.69**

Table J. VeriQ 4122 with PS probe and service costs - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-109.14	-107.69	-96.65	12.49
Mean No. of probes per procedure		1.4	1.7	2		-128.43	-107.69	-86.94	41.49
Rate of pats with revisions		2.20%	6.58%	14.60%		-112.85	-107.69	-98.24	14.61
Duration of minor revisions, min		2	2.5	5		-107.73	-107.69	-107.45	0.29
Duration of major revisions, min		27	42	57		-110.37	-107.69	-105.00	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-109.34	-107.69	-106.09	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-107.69	-107.69	-107.69	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-121.94	-107.69	-93.43	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-107.69	-107.69	-107.69	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-154.33	-107.69	-61.05	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-149.01	-107.69	-66.33	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-316.56	-107.69	51.75	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-127.69	-107.69	-87.69	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-212.37	-107.69	-30.63	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-114.14	-107.69	-104.35	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-107.75	-107.69	-107.63	0.12

Table K. VeriQ 4122 PQ probe with service costs - base case

Resource factor V3 1582 service	CABG w/TTFM			CABG			Difference		
	Value	Unit	cost (£)	Value	Unit	Cost (£)	Value	Unit	Cost (£)
TTFM									
Duration of TTFM for 3 grafts	2.35	Min		0	Min		2.35	Min	
CABG team TTFM cost per patient			9.79			0.00			9.79
Probes used	1.7	probes		0	probes		1.7	probes	
Probe cost			81.7			0.00			81.70
Cost of TTFM use per patient			**91.49**			**0.00**			**91.49**
Consequences of TTFM use									
Revision rate, %	6.58%			0.00%			6.58%		
Minor revisions, %	2.29%			0.00%			2.29%		
Major revisions, %	4.30%			0.00%			4.30%		
Duration of minor revisions	2.5	Min		0	Min		2.5	Min	
Rate of minor revisions	2.29%			0.00%			2.286 %		
CABG team cost for minor revisions			10.41			0.00			10.41
Team cost of minor revision per patient			**0.24**			**0.00**			**0.24**
Duration of major revisions	42.0	Min		0.0	Min		42.0	Min	
Rate of major revisions	4.30%			0.00%			4.30%		
CABG team cost for major revisions			174.93			0.00			174.93
Team cost of major revision per patient			**7.52**			**0.00**			**7.52**
Sum of TTFM costs			**99.24**			**0.00**			**99.24**

Consequences of not doing TTFM					
Intraoperative issues:					
Re-exploration of bleeding, rate	3.00%		3.00%	0.00%	
Re-exploration of bleeding, cost		180.41		180.41	0.00
Per patient cost, re-exploration of bleeding		**5.41**		**5.41**	**0.00**
Deep sternal infection, rate	1.00%		1.00%	0.00%	
Deep sternal infection, cost		860.55		860.55	0.00
Per patient cost, DS infection		**8.61**		**8.61**	**0.00**
IABP, rate	1.00%		7.00%	-6.00%	
IABP, cost		2657.37		2657.37	0.00
Per patient cost, IABP		**26.57**		**186.02**	**-159.44**
Postoperative issues:					
Perioperative MI, rate	0.00%		5.00%	-5.00%	
Perioperative MI, cost		1415.20		1415.20	0.00
Rehab after MI, cost		251.76		251.76	0.00
Per patient cost, MI		**0.00**		**83.35**	**-83.35**
Sum of consequence costs		**40.59**		**283.38**	**-242.79**
Sum of all costs		**139.83**		**283.38**	**-143.55**

Table L. VeriQ 4122 with PQ probe with service costs - sensitivity analysis

	Variable values								Width of interval
Variable	Best Case		Base Case	Worst Case		Delta Cost values, £			£
Duration of TTFM per procedure, min		2	2.35	5		-145.00	-143.55	-132.51	12.49
Mean No. of probes per procedure		1.4	1.7	2		-157.96	-143.55	-129.13	28.84
Rate of pats with revisions		2.20%	6.58%	14.60%		-148.71	-143.55	-134.10	14.61
Duration of minor revisions, min		2	2.5	5		-143.59	-143.55	-143.31	0.29
Duration of major revisions, min		27	42	57		-146.23	-143.55	-140.86	5.37
Relative rate of minor revisions		50.0 %	34.7 %	20.0 %		-145.20	-143.55	-141.95	3.25
Re-operative procedures, cost (£)		288.00	180.41	80.00		-143.55	-143.55	-143.55	0.00
Re-operative procedures, rates	0.6 %	8.5 %	3.0 %	8.5 %	0.6 %	-157.80	-143.55	-129.29	28.50
Deep sternal infection, cost (£)		1425.00	860.55	687.00		-143.55	-143.55	-143.55	0.00
Deep sternal infection, rates	0.0 %	5.5 %	1.0 %	5.5 %	0.0 %	-190.19	-143.55	-96.91	93.28
IABP, cost (£)		3346.00	2657.37	1968.00		-184.87	-143.55	-102.19	82.68
IABP, rates	0.0 %	13.9 %	1.0 %	3.5 %	3.5 %	-352.42	-143.55	15.89	368.31
MI, costs (£)		2067.00	1666.96	1267.00		-163.55	-143.55	-123.55	40.00
MI, rates	0.0 %	11.3 %	0.0 %	2.5 %	2.5 %	-248.23	-143.55	-66.49	181.74
Cost of CABG team composition, (£)		2.63	4.16	4.96		-150.00	-143.55	-140.21	9.79
On-pump rate		70.0 %	80.0 %	90.0 %		-143.61	-143.55	-143.49	0.12

EXTERNAL ASSESSMENT CENTRE SUPPLEMENTARY REPORT

Title: VeriQ system for assessment of graft flow during coronary artery bypass graft (EP119) - Tabular summary of clinical effectiveness evidence of predecessor devices (Medi Tech) to the VeriQ system

Produced by	*KCARE (EAC331)*
Home unit	*King's College Hospital NHS Foundation Trust, London*
Authors	*Chris Lawinski, Consultant Physicist, KCARE.* *Donald Emerton, Project Manager, KCARE.*
Contribution of Authors	*Chris Lawinski, reviewed the literature, prepared the report and reviewed and edited drafts of the report.* *Donald Emerton planned the project and reviewed drafts of the report.*
Correspondence to	*Donald Emerton, KCARE, Department of Medical Engineering and Physics, King's College Hospital Denmark Hill, London, SE5 9RS.*
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Notes on the tables: The study numbers in the tables in this report refer to the order of studies in the full External Assessment Centre report (EP119). Study 14 Jokinen et al. 2010 is from the studies originally submitted by the manufacturer; Study 1 Desai et al. 2008, Study 2 Balacumaraswami et al. 2005 and Study 3 D'Ancona et al. 2000 are the three additional studies identified by the EAC; the remainder of the studies are relevant studies selected from the 27 additional studies provided by the manufacturer. The nominal order of the studies in the table is comparative studies, cohort studies, case studies, reviews. Within each category the studies are in date order (most recent study first).

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 6 - Hatada at al. *General Thoracic and Cardiovascular Surgery*. 59(1), 14-18, 2011.	Comparative study.	Prospective comparison of diagnostic accuracy of harmonic distortion in TTFM waveforms and IFI to determine graft failure.	6 patients (10 grafts).	BF1000 (MediStim) TTFM. Comparator - SPY intra-operative fluorescence imaging (IFI) system (Novadaq Tech). Patients also underwent post-operative angiography.	Prior to 2008.	All patients underwent X-ray coronary angiography 1 to 2 months after leaving the hospital.	None.	IFI demon-strated a satisfactory flow in all grafts. X-ray angiography demonstrated that one SVG was 75% stenosed and the others were patent. Using TTFM, the mean graft flow and the PI of the patent SVGs were not significantly different from those of the stenosed SVG. The harmonic distortion of the patent SVGs was significantly different from that of the stenosed SVG.	Harmonic distortion of TTFM waveform can provide better diagnostic accuracy for detecting the quality of grafts than either graft flow or pulsatility index (using TTFM) or the use of intra-operative fluorescence imaging (IFI). This was a preliminary study and the number of cases needs to be increased. Problems such as whether the kind of graft affects the waveform need to be investigated.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 1 - Desai et al. *Journal of Cardiovascular Surgery.* 132(3), 585-594, 2006, E-publication 28 July 2008.	Randomised comparative study	Comparison of TTFM with intra-operative fluorescence imaging (IFI) for assessing coronary artery bypass graft patency. Patients randomly assigned to TTFM or IFI.	106 patients (139 grafts).	BF2004 (MediStim) TTFM. Comparator - Intra-operative fluorescence imaging (IFI) plus post-operative angiography.	2004- 2005.	Post-operative angiography after 3 to 8 days for 45 patients (after 76 days for 1 patient).	Non reported.	12 (8.2%) of grafts were demonstrated to have a 50% or greater stenosis. 2 false positives were identified. Sensitivity and speciificity of IFI and TTFM to detect greater than 50% stenosis were 83.3% and 100%, and 25% and 98.4% respectively.	TTFM is rapid and simple to use but the technique does not produce an image. Inter-pretation of flow data can be difficult. Intra-operative fluorescence imaging (IFI) provides greater diagnostic accuracy than TTFM for detecting graft errors.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 2 - Balacumaraswami L et al. *Journal of Thoracic and Cardiovascular Surgery.* 130(2), 315-320, 2005.	Comparative study.	Comparison of TTFM with intra-operative fluorescence imaging (IFI) for assessing. intra-operative graft patency during CABG procedures.	266 grafts in 100 CABG patients.	BF2004 (MediStim) TTFM. Comparator - Intra-operative fluorescence imaging (IFI).	Prior to 2005.	None.	Non reported.	Good correlation between TTFM and IFI in 96% of grafts including 8 (3%) in patients who required revision. IFI and TTFM confirmed adequate flow in 241 (91%) grafts in 75 (75%) patients and poor flow in 7 (2.6%) grafts in 7 (7%) patients. In 10 (3.8%) grafts in 10 (10%) patients TTFM indicated poor flow wheras IFI indicate satisfactory flow. These grafts were not revised.	In most patients both IFI and TTFM are useful in confirming intra-operative graft partency. In a small proportion of patients (10%) graft patency assessment with TTFM alone may prompt unnecessary graft revision.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 1 - Beran et al, *European Journal of Cardiothoracic Surgery*, In press,2010.	Retrospective cohort study.	Value of intra-operative bypass graft flow measure-ments for long-term mortality.	1593 CABG patients	CardioMed (MediStim) TTFM. Comparator - Pre-operative left ventricular ejection fraction measured using echo-cardiography.	1998-2006.	0.5 to 8.8 years (mean 3.8 years).	No losses to follow-up. Overall total long term all cause mortality 161 (10.1%) patients.	The preoperative left ventricular ejection fraction (LVEF) (echo-cardiograph) was the highest independent predictor of long-term survival (hazard ratio 0.97, p = 0.004).	The pre-operative left ventricular ejection fraction is a better predictor of long-term survival. TTFM is a useful tool in performing surgical quality control. TTFM is considered less time consuming and less invasive than other methods, eg immediate post-operative coronary angiography.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 14 - Jokinen et al. *European Journal of Cardiothoracic Surgery*. In press, corrected proof available online, 20 November 2010	Retrospective cohort study.	Pedictive value of TTFM assessed post-operatively with regard to short-term graft patency and long-term patient survival.	75 CABG patients (204 grafts).	MediStim TTFM (likely to be an earlier system that the VeriQ as data collected prior to 2004). Comparator - post-operative angiography	2001-2002.	Post-operative angiography after 22 to 34 weeks. Patients followed-up over 8 years.	16 deaths over 8 years.	166 grafts were patent and 29 were occluded. The mean flow was 45ml/min for the patent grafts and 38 ml/min for the occluded grafts. The medians of the PI values were 3.3 and 2.2. The highest sensitivity (72%) and specificity (70%) were associated with a PI value >3.0. 49 out of 70 such grafts were found to be patent.	Although TTFM does not produce an image or depict the nature of any technical graft-related problems, it fulfils most of the needs of a good intra-operative tool for quality assessment in CABG procedures. The authors concluded that transit time flowmetry can predict graft failure within six months after CABG but does not predict long-term outcome.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 9 - Takami et al. *Journal of Thoracic and Cardiovascular Surgery*. 138, 669-673, 2009.	Retrospective cohort study.	Flow characteristics of right gastroepiploic arterial grafts, investigated.	111 CABG patients.	BF2000 (MediStim) TTFM. Comparator - Post-operative angiography.	2004-2006.	Post-operative angiography after 1 month.	None.	A comparison of transit time flow data for functional patent in situ arterial grafts gave the following Pulsatility Index (PI) values; 2.8 ± 1.6 for GEA, 2.1 ± 0.9 for LITA and 2.4 ± 1.3 for RITA.	Intra-operative TTFM profiles of the functional in situ GEA grafts were variable and can be classified into four types, closely associated to the disease severity.The findings may help surgeons to judge the anastomosis quality of grafts in the operating room.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 10 - Nordgaard et al. *Annals of Thoracic Surgery*. 87, 1409-1415, 2009.	Retrospective cohort study.	Evaluation of mean blood flow and pulsatility index (PI) of sequential saphenous vein grafts in a large population of CABG patients.	581 patients (1390 grafts).	MediStim TTFM. Comparator - None.	2000-2005.	None.	None.	Flows measured in single vein grafts were significantly lower than in double (p <0.001) and triple sequential vein grafts (p <0.001). The mean PI of vein grafts was lower in the left versus the right coronary system, 2.0 ± 0.01 and 2.4 ± 0.06, respectively (p <0.001).	Significant differences in flow were measured in single or sequential vein grafts. Blood flow increases from single to double and up to triple sequential grafts. The PI of the right coronary system is significantly higher than that of grafts to the left coronary system.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 11 - Weber et al. *Journal of Cardiac Surgery*. 24, 2-5, 2009.	Retrospective cohort study.	Examination of the use of the internal thoracic artery over the saphenous vein for re-vascularisation of the circumflex or right coronary artery.	306 patients.	BF2004 (MediStim) TTFM. Comparator - None.	2001-1003.	None.	None.	The mean PI was signific-antly better for the single ITA/Cx-grafts (2.8 ± 1.9, n = 92) than for the single SV/Cx-grafts (3.3 ± 1.7, n = 43, p <0.05), whereas the mean flow did not differ Similarly, the mean PI was significantly better for the single ITA/RCA-grafts (2.2 ± 1.2, n = 36) than for the single SV/RCA-grafts (3.4 ± 2.6, n = 178, p < 0.01), whereas the mean flow did not differ.	The internal thoracic artery (ITA) provides superior flow properties than the saphenous vein (SV) to the circumflex (Cx) or right coronary artery (RCA) areas with reduced peri-operative ischemia. Further investigation is required to assess whether this advantage persisted after adjusting for the grade of the proximal coronary stenosis.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 12 - Tokuda et al. *Annals of Thoracic Surgery*. 86, 532-536, 2008.	Retrospective cohort study.	The ability of TTFM in predicting mid-term graft failure was assessed.	51 CABG patients (104 grafts).	BF1001 (MediStim) TTFM. Comparator - Post-operative angiography.	2002-2006.	Early post-operative angiography (6 to 68 days) and post-operative angiography at between 1 and 4 years after surgery.	None.	Of the 104 grafts, 21 were found to have a new, mid term occlusion or worsening of stenosis. Univariate analysis revealed that a lower mean flow (p <0.001) and a higher percentage of backward flow (p <0.05) measured using TTFM is a risk factor for predicting mid term graft failure.	The study demonstrates significant correlation between abnormal TTFM values and mid-term graft failure. TTFM provides a good prognostic index for both early and midterm follow-up.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 13 - Herman et al. *Interactive CardioVascular and Thoracic Surgery*. 7, 582-585, 2008.	Retrospective cohort study.	The assessment of the predictive value of measured graft flows on early and medium term postoperative outcomes.	985 CABG patients.	Butterfly Flowmeter (MediStim). Comparator - None.	2002-2005	Follow-up for a mean duration of 1.8 years.	Overall in-hospital mortality 4.7%.	Any PI ≤5 was considered to be normal flow. 19% of patients had abnormal flow in more than 1 graft. Outcome for adverse cardiac events was more prevalent in the abnormal flow group (31% vs 17%; *P* <0.0001).	The study not designed to test ability of TTFM to identify graft problems but to look at short and mid-term outcomes with intra-operative TTFM. In summary 0.9% of patients were shown to have abnormal flow which prompted surgical graft revision.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 14 - Balacumaraswami et al. *Journal of Thoracic and Cardiovascular Surgery*. 135, 533-539, 2008.	Retrospective cohort study	Value of intra-operative flow measure-ments on patients undergoing off-pump and on-pump surgery investigated using TTFM.	100 CABG patients (266 grafts) Off-pump 80 patients (203 grafts) On-pump 20 patients (63 grafts.	BF2004 (MediStim). Comparator - None.	2003-2004.	None	N/A	Overall, mean graft flow (ml/min) was higher for all grafts in the on-pump group ($p < 0.05$). Overall mean graft flow was significantly greater in the long saphenous vein than in the internal thoracic artery ($P < 0.001$) and radial artery ($P = 0.001$) but there was no significant difference in mean graft flow in internal thoracic artery or radial artery grafts within each group.	The study demonstrated significant differences in measured TTFM parameters (such as mean graft flow) for different patient groups and different clinical conditions. The authors support the need to assess intra-operative graft flow in order to detect and correct graft failure.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 15 - Tokuda et al. *Annals of Thoracic Surgery*. 84:1928-1933, 2007.	Retrospective cohort study	Evaluation of TTFM with early angiographic control.	123 patients (261 grafts).	BF1001 (MediStim) TTFM. Comparator - Post-operative angiography within 3 months of surgery.	2002-2006.	Post-operative angiography after 4 to 28 days.	None.	From ROC curve analysis for grafts to left coronary arteries, a mean flow of 15 ml/min or less, a PI of 5.1 or higher, and a % backward flow of 4.1% or higher were found to be the optimal cut-off criteria to predict early graft failure. Similarly, for the grafts to right coronary arteries, the cut-off values were 20 ml/min, 4.7, and 4.6% respectively.	Specific cut-off values of criteria in TFFM for predicting early graft failure are established. TTFM may be a useful method of predicting early graft failure. However, to avoid unnecessary graft revision, surgeons should exercise caution when interpreting abnormal results.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 17 - Di Giammarco et al. *Journal of Thoracic and Cardiovascular Surgery*. 132, 468-474, 2006.	Retrospective cohort study.	Evaluation of the possibility of predicting post-operative graft patency in coronary surgery with intra-operative TTFM.	157 patients (304 grafts).	CarioMed (MediStim) TTFM. Comparator - Post-operative angiography.	1997-2003.	Post-operative angiography after 2 to 12 months.	None.	The mean flow (MF) of the total group was 28 ± 21 ml/min. 105 grafts had a MF of ≤15 ml/min. The mean PI value was 3.2 ± 5.9. The % backwards flow (BF) value was 3.6 ± 9.0%. Failed grafts had significantly lower MF values along with higher PI and %BF values compared with those of the patent grafts at univariate and multivariate analysis.	The combination of various TTFM parameters results in the chance of predicting graft failure within the first post-operative year. TTFM represents a quick, easy, and reproducible method for intra-operative evaluation of graft function. MF values ≤15 ml/min, PI values ≥3.0, %BF values ≥3.0% and the absence of BF represent independent variables for higher incidence of graft failure at follow-up.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 18 - Gwozdziewicz et al. *Annals of Thoracic Surgery*. 82, 620-623, 2006.	Retrospective cohort study.	The aim of this study was to determine flow characteristics of individual and sequential bypass grafts created on the beating heart.	50 patients.	CM4008 MediStim TTFM. Comparator - None.	2003-2004.	Not reported.	None.	The mean flow (MF) through the distal anastomoses (individual bypass) was 37.4 ml/min. After the creation of a proximal side-to-side an-astomosis, the MF through the distal an-astomosis was 39.0 ml/min (p >0.9). The MF through the proximal an-astomoses of the sequential bypass was 36.9 ml/min. The MF through the sequential graft was 69.4 ml/min.	The flow through an individual bypass is comparable with that through the distal segment (end-to-side anastomosis) of a sequential bypass. The grafting of a sequential bypass proximally to the larger artery in sequence does not appear to have a significant effect on the blood flow in the distal segment of a sequential bypass.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 19 - Kim et al. *Annals of Thoracic Surgery*. 80, 594-599, 2005.	Retrospective cohort study.	Validity of intra-operative TTFM in predicting graft flow abnormalities was assessed.	58 patients.	BF1001 (MediStim) TTFM. Comparator - Post-operative angiography.	2000-2001.	Early post-operative coronary angiography after 1 to 2 days.	None.	When the criteria for detection of abnormal graft flow (mean flow <15 ml/min and PI >3 in the left coronary territories and >5 in the right coronary territories) were applied, the sensitivity and specificity of TTFM to detect the graft flow abnormality were 96.2% and 76.9%, respectively.	Graft abnormality can be predicted and graft patency improved by revising the anastomosis intra-operatively from an interpretation of TTFM variables. The results suggest that TTFM is a reliable tool for predicting graft flow impairment.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 20 - Leong et al. *Annals of Thoracic Surgery*. 79, 854-857, 2005.	Retrospective cohort study.	Ability of TTFM to detect technical errors in grafts, to measure the mean flow and to compare arterial and vein grafts.	116 patients (323 grafts).	Butterfly Flowmeter (MediStim). Comparator - None.	2001-2002.	Not reported.	None.	In the grafts that were revised, the mean graft flow increased significantly after correction from 5.4 ± 3.7 ml/min to 26.4 ± 8.2 mlmin ($p < 0.05$). The PI decreased significantly after correction from 11.3 ± 5.9 to 3.1 ± 1.3 ($p <0.05$). Mean flow normals were determined for Asian patients.	TTFM gives important and accurate intra-operative information about the status and patency of each individual graft. TTFM enables technical problems to be diagnosed accurately, allowing prompt revision of grafts. It should be mandatory in CABG procedures to improve surgical outcomes.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 21 - Kjaergard et al. *Annals of Thoracic Surgery*. 78, 2054-2056, 2004.	Retrospective cohort study.	The measurement of blood flow in coronary artery bypass grafting conduits on-pump and off-pump and the estimation of the total conduit Flow.	217 patients (120 patients on-pump, 97 patients off-pump).	CardioMed CM1005 (MediStim) TTFM. Comparator - Directly measured blood flow and Doppler ultrasound methods (both from other studies).	2000-2004.	Not reported.	None.	In men the left internal mammary artery flow was 33.7 ± 2.0 ml/min on- and 34.4 ± 2.9 off-pump (p >0.05). In women it was 29.4 ± 3.0 ml/min and 22.8 ± 1.9 (p >0.05). In men the vein graft flow per anastomosis was 30.4 ± 1.3 ml/min on- and 37.8 ± 5.4 off-pump (p >0.05). In women it was 28.0 ± 2.9 ml/min and 23.2 ± 2.9 (p >0.05).	There are no major differences in the vessel flow on- versus off-pump. In women, the mean conduit flows are numerically lower than in men. TTFM shows good correlation with directly measured blood flow and Doppler ultrasound and is more applicable for clinical measurements than the other methods. Also, conventional CABG on-pump may restore up to about half of the normal resting coronary artery blood flow.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 22 - Gwozdziewicz M. *Biomedical Papers*. 148, 59-61, 2004.	Retrospective cohort study.	Evaluation of the quality of aortocoronary bypass grafts done on the beating heart and consequently their good patency.	50 patients (180 grafts).	CardioMed CM4008 (MediStim) TTFM. Comparator - None.	2003-2004.	Not reported.	None.	All sequential bypasses showed good per-operative quality with a mean flow of 69.4 ± 29.0 ml/min. The flows through the proximal and distal segment of the sequential graft were, on average, 36.9 ± 18.7 and 39.0 ± 23.7 ml/min, respectively. All measured PI values remained below the approved level of 5.0.	Graft patency verification with TTFM is a great contribution to cardiovascular surgery and a means of preventing early coronary graft occlusion. It is possible that aortocoronary graft's flow and pulstility index (PI) values from TTFM will be a routine part of the surgical protocol in every patient.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 3 - D'Ancona G, et al. *Annals of Thoracic Surgery.* 69, 1300-1301, 2000.	Retrospective cohort study.	Assessment of the clinical applicability of TTFM in detecting anastomotic imperfections following myocardial revascularization in off-pump coronary artery surgery.	409 patients (1145 grafts).	BF 2004 (Medistim) TTFM. Comparator - None.	1997-1998.	Non reported.	3 patients (flow data not properly stored).	41 grafts were revised in 33 patients. After revision, all flow patterns improved and mean flow values increased from a mean value of 3.85 ± 4.63 to 32.47 ± 28.59 ml/min with proximal snare (P >0.0001) and from 6.58 ± 6.00 to 36.29 ± 26.91 ml/min without snare (P >0.0001). PI values also improved from 38.45 ± 56.56 to 3.03 ± 1.60 with snare and from 24.44 ± 46.51 to 2.80 ± 1.68 without snare (P >0.0001).	TTFM is reliable in detecting technical errors after off-pump CABG. Evaluation of TTFM is valuable in determining the status of a coronary graft after CABG. Correct interpretation of flow patterns allows for correction of abnorm-alities prior to chest closure. There is still necessity to define the sensitivity of TTFM in detecting less then critical stenoses.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 27 - D'Ancona et al. *Heart Surgery Forum*. 2(2), 121-124, 1999.	Retrospective cohort study.	Assessment of the surgical results of beating heart CABG using TTFM and the development of a standard algorithm for using and interpreting intra-operative TTFM.	160 patients (323 grafts).	BF2004 (MediStim) TTFM. Comparator -	1998.	Approximately 1 year.	None.	A standard algorithm for utilizing intra-operative TTFM data was developed. Accordingly, 32 grafts (9.9%) were revised. 6 (18.8%) were found to be completely obstructed, 9 (28.1%) had minimal stenosis, 12 (37.5%) had an intimal flap or a clot in the native coronary, in 5 (15.6%) the conduit was kinked or a dissection of the LIMA was found.	All the grafts revised as a result of TTFM were found to have a significant technical error. All revised patients recovered without acute myocardial infarction. All patients were alive and symptom free at follow-up. Based on the favourable use of TTFM, the authors strongly recommend that patency of every graft be assessed whether the operation is performed off-pump or on-pump.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 25 - Walpoth et al. *Annals of Thoracic Surgery*. 66(3), 1097-1100, 1998.	Retrospective cohort study.	Study of intra-operative graft flow and vascular resistance in patients with coronary artery disease.	46 patients.	CardioMed CM 4008 (MediStim) TTFM. Comparator - None.	Prior to 1998.	Not reported.	None.	43 of the 46 patients showed normal graft flow (>20 ml/min); 3 patients had no or minimal graft flow. Re-doing the graft anastomosis in the 3 patients resulted in normalization of graft flow. The mean flow increased significantly after correction from 0.5 ± 0.7 ml/min to 15.7 ± 9.6 ml/min (p <0.02). PI decreased from 146.9 ± 95.7 to 3.4 ± 1.8 p <0.001).	Measurements of intra-operative flow and resistance allow assessment of early graft function and helps to prevent graft failure and reduce peri-operative infarction. Transit time volume flow may be a simple tool for quality control in coronary bypass procedures.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 23 - Walpoth et al. *European Journal of Cardiothoracic Surgery*. 10(12), 1064-1068, 1996.	Retrospective cohort study.	Measurement of internal mammary artery graft flow with TTFM, the comparison of two surgical take-down techniques and the quantisation of TTFM compared to free pedicle flow.	20 patients divided into 2 groups of 10 using either skeletonizing of the internal mammary artery (group A) or a classical pedicle preparation technique (group B).	CardioMed (MediStim) TTFM. Comparator - None.	Prior to 1996.	Not reported.	None.	Severe vaso-constriction of the internal mammary artery was detected in both groups. Papaverine soaking caused a moderate flow increase (up to 40%). After coronary grafting, TTFM showed no significant differences between the two groups. A linear correlation was demonstrated between TTFM and simultaneously measured free flow (r = 0.89).	A wide range of TTFM measurements were made including at the beginning and end of take-down, after papaverine soaking and free flow into a beaker. TTFM is a reliable method for assessing internal mammary artery and coronary artery bypass flow. Considering the simple technical application, TTFM may be regarded as a valuable instrument of quality control.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 24 - Laustsen et al. *European Journal of Vascular and Endovascular Surgery*. 12(1), 91-96, 1996.	Retrospective cohort study.	To validate the CardioMed CM 4000 TTFM system for intra-operative measurement of volume blood flow in vivo in man	25 patients.	CardioMed CM 4000 (MediStim) TTFM. Comparator - Direct measurement of blood flow by exsanguination from the cut vein.	Prior to 1996.	Not reported.	None.	Within the examined blood flow range, the volume blood flow determined by TTFM (y) corresponded to the directly measured blood flow (x). For in situ saphenous vein grafts y = -2.4 + 0.95x (r = 0.99) and for internal thoracic artery grafts y = -9.6 + 1.1x (r = 0.99). Fistula detection was easy and swift.	Within the examined blood flow range, the measurements determined by TTFM agreed closely to the directly measured blood flow. TTFM is simple to use during intra-operative procedures and gives fast, precise measurements of volume blood flow.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 7 - Economopoulos et al. Journal of Cardiac Surgery. 25, 176, 2010.	Single case study.	Suspected subclavian artery stenosis based on measured parameters from TTFM	1 patient	BF2000 (MediStim) TTFM. Comparator - Post-operative CT angiography.	Prior to 2010.	Post-operative CT angiographic evaluation	None.	A 71-year-old man urgently underwent off-pump CABG surgery. A subclavian artery stenosis was suspected from TTFM measurements and the LIMA was then used as a free graft from the ascending aorta to the LAD. A TTFM study of the free LIMA graft showed a flow pattern with an acceptable PI and a satisfactory mean flow.	Post-operative CT angiographic evaluation demonstrated a severely calcified stenotic lesion in the proximal left subclavian artery. Conventional angiography confirmed the presence of a hemodynamically significant proximal left subclavian artery stenosis.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 3 - Mack MJ. *Current Opinion in Cardiology*. 23(6), 568-72, 2008.	Review.	Comparison of techniques for assessment of CABG.	Review of results from a range of studies from different authors.	MediStim and Transonic TTFM. Comparator - Intra-operative fluorescence imaging (IFI), intra-operative coronary angiography.	Prior to 2008 (range of studies).	N/A	N/A	Intra-operative graft flow assessment by various techniques shows a remarkably consistent finding of a graft occlusion rate between 2% and 5%. Immediate post-operative assessment of graft patency demonstrates a graft failure rate of up to 9%.	TTFM provides an objective measurement of graft flow. However, this technique may be more sensitive to other factors (compared to IFI) that may cause underestimate or over-estimate of need for graft revision. Wider use of TTFM (and IFI) may reduce graft failure although intra-operative coronary angiography remains the gold standard option for immediate graft assessment.

Study Name	Design	Purpose	Patient Population	Intervention & comparator	Dates of patient enrolment	Follow-up	Patient Drop-out	Outcomes	Conclusions
Study 16 - Balacumaraswami et al. Annals of Thoracic Surgery. 83, 2251-2257, 2007.	Review	Comparison of TTFM and Intra-operative fluorescence imaging (IFI) for assessment of CABG. Dis-cussion of values and limitations.	TTFM - 7 studies with 100 patients or more (including 1 study by the authors). IFI - 6 studies with 20 to 200 patients.	MediStim TTFM used by the authors and in several of the other studies reviewed. Comparator - Intra-operative fluorescence imaging.	TTFM - 1999-2005 (authors' study 2005). IFI - 2002-2005.	N/A	N/A	Intra-operative graft occlusion is a consistent finding affecting up to 5% of grafts and contributes to adverse outcomes in the short and long term. Detection of internal thoracic artery occlusion is of particular relevance because of its adverse prognostic implications, and reinforces the need for intra-operative assessment of graft patency to allow revision when needed.	Both TTFM and IFI can reliably detect occluded grafts but can not consistently detect minor abnormalities. TTFM provides a more objective measurement of graft flow compared to IFI but is more likely to under- or over-estimate the need for graft revision.

EXTERNAL ASSESSMENT CENTRE SUPPLEMENTARY REPORT

Title: VeriQ system for assessment of graft flow during coronary artery bypass graft: Summary of additional supporting evidence.

Produced by	*KCARE (EAC 331)*
Home unit	*King's College Hospital NHS Foundation Trust, London*
Authors	*Chris Lawinski, Consultant Physicist, KCARE*
Contribution of Authors	*Chris Lawinski reviewed the literature and prepared the report.*
Correspondence to	*Donald Emerton, Project Manager, KCARE, Department of Medical Engineering and Physics, Faraday Building, King's College Hospital, Denmark Hill, London, SE5 9RS*
Date completed	*June 2011*

Declared interests of the authors

None

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Rider on responsibility for report

The views expressed in this report are those of the authors and not necessarily those of the Centre for Health Technology Evaluation. Any errors are the responsibility of the authors.

Summary of additional supporting evidence

The manufacturer also submitted evidence relevant to the decision problem on predecessor devices of the VeriQ system. Three further studies which were considered relevant were identified by the EAC. These MediStim predecessor devices (CardioMed (CM) and Butterfly Flowmeter (BF) ranges) used the same TTFM principle to measure graft flow in CABG patients. The EAC has reviewed these studies and considers them as relevant to determining the value of TTFM for graft flow with the VeriQ system.

A list of the 26 relevant studies can be found in Appendix 1 of this report.

Comparative studies

Three comparative studies evaluate TTFM against intra-operative fluorescence imaging (IFI) and additionally, in two cases, post-operative X-ray angiography. The studies showed variable findings but all authors suggested that TTFM was a comparatively simple technique to use. Good correlation between measurements by TTFM and IFI was found by Balacumaraswami et al (2005). However, in a small proportion of patients (10%) it was suggested that graft patency assessment with TTFM alone might prompt unnecessary graft revision. Desai et al (2006) concluded that IFI gave better diagnostic accuracy for detecting graft errors than TTFM and that the difference in sensitivity between the two techniques was significant (p=0.023). Hatada et al (2011) suggested that measurement of the harmonic distortion of the TTFM waveforms was more accurate than IFI or mean flow and pulsatility index from TTFM.

Cohort studies

The 20 retrospective cohort studies (1996 to 2010) used TTFM for a range of applications.

Assessment of short term graft failure and long term patient survival

Five studies examined the value of TTFM in predicting short term graft patency, medium term outcomes and long term patient survival.

Jokinen et al (2010) assessed the value of TTFM in terms of short-term graft patency and long-term patient survival (204 grafts). The authors suggested that although TTFM does not provide an image or depict the nature of any graft-related problems, it fulfills a most of the needs of a good intra-operative tool for quality assessment in CABG procedures. Further, TTFM can predict graft failure within six months of the CABG but does not predict a long-term outcome.

Beran et al (2010) reviewed the value of TTFM with respect to the long-term mortality in over 1500 patients. However, the authors considered that the pre-operative left ventricular ejection fraction (echo cardiography) was a better independent predictor of a long-term survival ($p=0.004$). However, TTFM was considered a useful tool in performing surgical quality control and is more rapid to perform than other methods.

Tokuda et al (2007) carried out an evaluation of TTFM using early post-operative angiographic control (261 grafts). Specific cut-off values of criteria in TTFM for predicting early graft failure were established. The authors suggested that TTFM was a useful method of predicting early graft failure. However, to avoid unnecessary graft revision caution needs to be exercised when interpreting abnormal results. The following year Tokuda et al (2008) showed significant correlation between abnormal TTFM values and mid-term graft failure (104 grafts, lower mean-flow ($p<0.001$) and higher % backward flow ($p<0.05$)). The authors suggested that TTFM provides a good prognostic index for both early and mid-term follow-up.

Hermann et al 2008 also used TTFM to assess the predictive value of a measured graft flow on early and medium-term outcomes (985 patients). Adverse cardiac events were found to be more prevalent in patients with abnormal flow ($p<0.0001$). Approximately 1% of patients were shown to have abnormal flow which prompted surgical graft revision.

Quality and patency of bypass grafts

Seven studies used TTFM as a tool for assessing the quality and patency of bypass grafts.

D'Ancona et al (1999) developed a standard algorithm for utilising and interpreting TTFM. Measurements were made on 323 grafts and all grafts revised as a result of TTFM (using this algorithm) were found to have significant technical error. In conclusion, the authors strongly recommended that the patency of every graft be assessed. In a later study, D'Ancona et al (2000) assessed the clinical applicability of TTFM in detecting imperfections in grafting procedures. 41 grafts (out of 1145) were revised and significant increases in mean flow ($p<0.0001$) and decreases in pulsatility index ($p<0.0001$) were found. This suggested that TTFM is reliable in evaluating the status of coronary grafts and detecting technical errors. However the authors suggested that there was still the necessity to define the sensitivity of TTFM in detecting less than critical stenoses.

Gwozdziewicz et al (2004) evaluated the quality and patency of bypass grafts using TTFM (180 grafts). It was concluded that TTFM was a great contribution to graft verification in cardiovascular surgery and the authors proposed that TTFM should be a routine part of the surgical protocol. Two years later, Gwozdziewicz et al (2006) investigated the flow characteristics of individual and sequential bypass grafts (in 50 patients) using TTFM and demonstrated differences between the flow in the different forms of bypass graft.

Leong et al (2005) reviewed the ability of TTFM to detect technical errors in grafts (323 grafts). It was shown that the mean graft flow increased significantly ($p<0.05$) and the pulsatility index decreased significantly ($p<0.05$) after correction. The authors concluded that TTFM enables technical problems to be diagnosed accurately, allowing prompt revision of grafts and suggested that it should be mandatory in CABG procedures to improve surgical outcomes.

Kim et al (2005) assessed the validity of intra-operative TTFM in predicting graft flow abnormalities in 58 patients. The authors concluded that abnormalities can be predicted by TTFM and hence graft patency improved by revision and suggested that the technique is a reliable tool for predicting graft flow impairment.

Di Giammarco et al (2006) assessed the possibility of predicting post-operative graft patency with TTFM (304 grafts). The combination and review of various TTFM parameters results in the chance of predicting graft failure within the first post-operative year. TTFM is a quick, easy and reproducible method of evaluating graft function.

On-pump versus off-pump techniques

Two studies examined and compared the blood flow in grafts using on-pump and off-pump techniques.

Kjaergard et al (2004) used TTFM to measure the blood flow in bypass grafts both on-pump (120 patients) and off-pump (97 patients) and found no significant differences ($p<0.05$). The authors also reviewed a number of other studies and concluded that TTFM showed good correlation with directly measured blood flow and with Doppler ultrasound methods, and it is more applicable for clinical measurements than the other methods.

Balacumaraswami et al (2008) reviewed the value of intra-operative flow measurements for patients undergoing both on-pump (63 grafts) and off-pump (203 grafts) CABG surgery. Significant differences in measured TTFM parameters were found for the two patient groups and for different types of graft ($p<0.05$ to $p<0.0001$). The authors supported the need to assess graft flow intra-operatively in order to detect and correct graft failure.

Types of graft

Blood flow and patency in various types of graft or classification of graft type was the subject of three studies.

Weber et al (2009) used TTFM to examine the use of grafts from different arteries or veins for re-vascularisation of coronary arteries (306 patients). Significant differences in pulsatility index were found ($p<0.01$ to $p<0.05$).

Norgaard et al (2009) used TTFM as a tool to compare flow in a single vein graft compared to that in double and triple vein grafts (total of 1390 grafts) and showed significant differences in flow ($p<0.001$).

Takami et al (2009) suggested that TTFM was useful tool (measurements on 111 patients) and that profiles of the function in in-situ grafts could be classified into four types closely related to the severity of the disease. The findings may aid surgeons in judging the quality of grafts.

Early studies

Three early studies were also reviewed.

Lautensen et al (1996) validated TTFM for intra-operative measurement of blood flow (25 patients) and compared it to direct measurement (exsanguination of blood flow from the cut vein). The TTFM values corresponded closely to the directly measured blood flow (r=0.99). TTFM was considered simple to use during intra-operative procedures, giving fast, precise measurements of volume blood flow.

In another early, study Walpoth et al (1996) made a wide range of measurements of mammary graft blood flow (20 patients) with the TTFM and in a number of cases compared the results to simultaneously measured free flow (into a beaker). A linear correlation was demonstrated between TTFM and free flow (r=0.89). TTFM was described as a reliable method for assessing internal mammary artery and coronary artery bypass flow. Considering the simple technical application, TTFM may be regarded as a valuable instrument of quality control. In a second study, Walpoth et al (1998) used TTFM to investigate intra-operative graft flow and vascular resistance in patients (46) with coronary artery disease. The mean flow increased significantly ($p<0.02$) and the pulsatility index decreased significantly ($p<0.001$) in patients that required graft revision suggesting that TTFM may be a simple tool for quality control in CABG procedures.

Case studies

In the single case study Economopoulos et al (2010) identified a suspected subclavian artery stenosis based on measured parameters from TTFM prompting grafting. A TTFM study of the graft showed a flow pattern with a satisfactory mean flow and an acceptable pulsatility index. Post-operative X-ray angiography demonstrated a significant stenosis in the subclavian artery.

Review studies

The two review studies compare TTFM, IFI and other techniques as methods of assessing graft flow in CABG surgery.

Balacumaraswami et al (2007) reviewed TTFM and IFI for the assessment of CABG patients and discussed the values and limitations of each technique. It was concluded that both TTFM and IFI can reliably detect occluded grafts but can not consistently detect minor abnormalities. TTFM provides a more objective measurement of graft flow compared to IFI but is more likely to under or over estimate the need for graft revision.

Mack (2008) reviewed various techniques for the assessment of CABG patients including TTFM, IFI and intra-operative angiography. It was concluded that although TTFM provides an objective measurement of graft flow, the technique may be more sensitive to factors that may cause underestimate or over estimate of need for graft revision. Wider use of TTFM or IFI may aid in reducing graft failure although coronary angiography remains the ‘gold standard’ option for graft assessment.

Conclusions

The three comparative studies suggest that TTFM is a comparatively simple technique to use. However, it is pointed out that TTFM might potentially prompt unnecessary graft revision and that IFI may provide better diagnostic accuracy.

The studies (five) reviewing short-term graft failure and a long-term patient survival indicate that TTFM is a useful tool for predicting early graft failure but there is no strong evidence for its ability to predict long term patient survival.

Seven studies used TTFM as a tool for assessing the quality of bypass grafts and in all cases the technique was considered a useful tool for measuring various parameters related to a blood flow. Significant differences were shown in normal and abnormal grafts.

Similarly, the two studies that used TTFM to compare on-pump and off-pump techniques and the three studies in which TTFM was used to compare types

of graft showed it to be a useful tool with significant differences in measured values for the various methods and grafts. The single case study showed TTFM to be a useful tool in identifying a suspected stenosis. Two of the early studies showed that TTFM gave flow values that corresponded closely to directly measured blood flow.

In one review it was concluded the both TTFM and IFI can reliably detect occluded grafts but cannot consistently detect minor abnormalities. Also, TTFM is more likely to under or overestimate the need for graft revision than IFI. The second review similarly suggested that although TTFM provides an objective measurement of graft flow, the technique is more liable to underestimate or overestimate the need for graft revision.

Several of the studies use post-operative X-ray angiography as a comparator as this technique it is still considered the ‘gold standard’ for graft assessment but is not the most convenient technique to perform. Routine clinical use of TTFM is suggested in a number of studies. The technique is considered a valuable method of quality control in CABG surgery and it is easier to perform and more rapid than most of the other methods.

Appendix 1: Additional studies submitted by the manufacturer or identified by the EAC

Balacumaraswami L, Abu-Omar Y, Choudhary B, Pigott D and Taggart DP. **A comparison of transit time flowmetry and intra-operative fluorescence imaging for assessing coronary artery bypass graft patency.** *Journal of Thoracic and Cardiovascular Surgery.* 130(2), 315-320, 2005.

Desai ND, Miwa S, Kodama D, Koyama T, Cohen G, Pelletier MP, Cohen EA, Christakis GT, Goldman BS and Fremes SE. **A randomized comparison of intra-operative indocyanine green angiography and transit-time flow measurement to detect technical errors in coronary bypass grafts.** *Journal of Cardiovascular Surgery.* 132(3), 585-594, 2006, E-publication 28 July 2008.

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Appendix E: Additional submission information table

National Institute for Health and Clinical Excellence
Additional Submission Information

[NICE331/EP119]

The purpose of this table is to show where the External Assessment Centre relied in their assessment of the topic on information or evidence not included in the original manufacturer submission. This is normally where the External Assessment Centre:

a) become aware of additional relevant evidence not submitted by the manufacturer
b) need to check "real world" assumptions with NICE's Expert Advisers, or
c) need to ask the manufacturer for additional information or data not included in the original submission

These events are recorded in the table to ensure that all information relevant to the assessment of the topic is made available to MTAC. The table is presented to MTAC in the Assessment Report Summary, and is made available at public consultation.

Submission Document Section/Sub-section number	Question / Request to Manufacturer or Expert Adviser *Please indicate whether Manufacturer or Expert Adviser was contacted. If an Expert Adviser, only include significant correspondence and include clinical area of expertise.*	Response ***Attach additional documents provided in response as Appendices and reference in relevant cells below.***	Action / Impact / Other comments
Manufacturer's submission Section 7.2.4	Manufacturer: 02/03/2011 Email request re: number of hits in the literature search.	Response received 02/03/2011 From Jon Lawrence (manufacturer) email response to the EAC.	No further action.
Manufacturer submission Section 5.2.4	Manufacturer: 02/03/2011 Email request for full text of five studies.	Response received 03/03/2011 From Victor Gonzalez (manufacturer) email response to the EAC.	No further action.
Clinical evidence	Conference call arranged by NICE: 15/03/2011.	Refer to NICE records.	Suppliers to submit further papers to support use of transit time flowmetry (TTFM).
Manufacturer's submission Section 6	Expert Adviser: 04/04/2011 Do you agree that minor revisions are correction of twists or kinks, cutting and obstructing pericardial edge or reversing a spasm take on average 2.5 to 5 minutes to revise?	Response received 10/04/2011 Most minor revisions, as described, will be obvious to the naked eye and will be usually addressed in a short period of time. It may well require graft refashioning, but this is not the remit of TTFM, and the timings are therefore irrelevant, as these	No Action required.

		procedures would be performed with or without this technology.	
	Do you agree that major revisions are re-doing anastomosis, attaching bypass directly to aorta, endarterectomy and replacing arterial with vein graft? Do you agree that the added time to perform major revisions depends on whether the CABG is performed on-pump or off-pump? If the CABG is on-pump, a major revision takes on average 45 minutes, if the CABG is off-pump it takes on average 30 minutes?	Major revisions will not be determined by on-pump or off-pump. An anastomotic revision will take a similar time, on-pump or off-pump. The time is all about decision making rather than the technical exercise. A graft revision top or bottom end will take 10 to 15 minutes. A total time of 30 minutes is appropriate as a maximum. These timings are appropriate wherever the surgery is performed.	
	The manufacturer has assumed that the staffing level for both on-pump and off-pump CABG procedures is: Surgeons x2 Anaesthetists x1 Perfusion staff x1 Anaesthetist nurses x 0 Cardiac nurses x 2 Is this correct?	The ideal is that these decisions are made at the time of the primary procedure not at 're-do' surgery. The numbers of staff quoted are appropriate.	
Cost model and table B10	<u>Manufacturer: 05/04/2011</u> The figures in the economic submission for Band 6 salaries	<u>Response received: 12/04/2011</u> We agree that there has been an error when entering the data for the pay of nurses on	Cost model reworked with correct figures. These were then used in the EAC report.

	are: £35,472 to £34189 (average: £34830.50p). The EAC found the correct figures them to be: £25.472 to £34.189 (average: £29.830.50p. Do you agree?	Band 6.	
Manufacturer's submission section 6	Manufacturer: 11/04/2011 The Economic model uses data from Dr Kieser's email and communications with Dr Bergsland. Was any financial incentive or reward offered by your company for them to participate in this work?	Response received: 12/04/2011 Written comment (email) from Dr Kieser (see appendix 1 below). References (oral) by Dr Bergsland were made to our Health Economist consultants by telephone and we are unaware of any transcripts. He is situated in Oslo. He has been working with us for many years and as far as we are aware, he has never received any financial support from us. We have loaned equipment to him and he has spoken for us on several occasions but as he was contacted by the Health Economist consultants I cannot say if he was reimbursed for any references we asked for in relation to this submission.	Email communication reviewed and data in submission confirmed.
Manufacturer's submission Section 6	Manufacturer: 27/04/2011 Quite a lot of data (nearly all the new data in the tables) has been highlighted in blue as commercial-in-confidence. The EAC has noticed that data which	Response received: 02/05/2011 We are sorry that it has been 'blanket highlighted'; we just highlighted all figures as sensitive data. Of course if the data is in the public domain (salaries, etc) then of course we do not need	Only truly commercial-in-confidence data has been highlighted and underlined in the EAC report.

	is freely available has been 'blanket highlighted', eg data derived from published papers or found on websites, particularly in table B10 and B16, even empty cells have been highlighted.	to highlight these as sensitive.	
Manufacturer's submission Section 6	Manufacturer: 09/05/2011 The cost of the probes appears to be based on a cost of £1500 from the Briefing note and not the cost £1582 in the submission.	Response received: 10/05/2011 We may have had a mix-up in the pricing structure of the probes. Please refer to the higher price, as this is correct.	Cost model reworked with correct figures. These results were then used in the EAC report.

Appendix 1. Copy of email from Dr Kieser to MediStim - 21/03/11

Hi Victor and Jon,
Thanks for your questions, after being here at the SCTS University meeting I now understand what is meant by "project with NICE". I will try to answer your questions one by one.

1. Time spent measuring TTF values: for grafts that are good and need no adjustment: 10-15 seconds /graft, with an average of 3 grafts/patient, each graft measured 3-4 times during the course of the operation would add 90-180 seconds or 1 1/2 to 3 minutes/operation. For off-pump procedures one additional graft measure may be done for each graft "with proximal snare" just once before protamine, (I don't like to snare after Protamine) so for off-pump cases an extra 30-45 seconds may be added giving a total of 120-225 seconds or approximately 2-3 1/2 minutes.

2. Number of persons needed for the TTF measures: usually just two: the surgeon and someone to enter the data of the patient on the VeriQ and record the flow curve assessment. (The scrub nurse will need just to receive the flow probe onto her table) In our institution this person is the perfusionist whether off or on pump. One note: I try to let the perfusionist and my scrub nurse know well in advance the flow probe size and the first graft that needs to be labelled for TTF measure. This way the data and first bypass labelling are already in place so that when I am ready to do the first (or any subsequent graft) measurement, one does not have to wait and can just put the probe on the graft, look at the display and anyone close by can press the "Save" button. I then ask the perfusionist to re-label for the next measurement so it is ready to go when I am ready to measure. This way there is very little "wait" time for the surgeon.

3. Time spent on actions triggered by TTF measurements is quite variable. From our paper " Transit-time flow predicts outcomes in coronary artery bypass graft patients: a series of 1000 consecutive arterial grafts" Eur J Cardiothorac Surg 2010 Aug;38(2): 155-62, we found that 93% of grafts had acceptable transit-time flow values so only 7% of grafts needed to have something addressed. In addition to these 7%, we did make corrections to 20 grafts, 5 minor and 15 major. Minor corrections included such manoeuvrings as correcting a twist, cutting an obstructing pericardial edge or reversing spasm of an arterial conduit usually the radial. These minor corrections would take about 2-3 minutes each which would include checking and recording TTF measures again.
The 15 major corrections included redoing the distal or proximal anastomosis, attaching the bypass directly to the aorta, performing endarterectomy or replacing the arterial conduit with a vein graft. For on-pump CABG surgery, any of these major corrections would take 30-60 minutes extra because the patient would have to be put on pump, aorta cross-clamped etc. to redo whatever needed to be redone. For off-pump cases, redoing a graft would range from 15 to 45 minutes depending on the location of the graft on the heart. (Lateral wall bypasses would take

longer to re-do, compared with grafts on the front of the heart.)

4. Cost of not doing graft revision can be divided into "patient cost" and "financial cost" Cost to patients include all of the major adverse events (MACE) listed in our paper: return of angina, myocardial infarction, need for percutaneous coronary intervention (PCI) or angioplasty, early re-operation and death. For financial cost you could cost out for the United Kingdom all of these extra procedures that might be needed for these events: i.e. the cost of PCI, re-operation, prolonged hospital stay anywhere from an extra 7-10 days to an extra 4-6 months. Patients with complications of needing urgent re-operative surgery often get many other complications such as pneumonia, renal failure, sepsis greatly prolonging their stay. These are just rough estimates but this information does come from some of the patients with high PI grafts and MACE from our paper. Also it is hard to cost out financially the cost of lives lost; death was the most significant MACE that occurred.

Hope this helps in your preparation for the proposal to NICE, please let me know if you need anything else,

Sincerely,

Teresa

Appendix F: Manufacturer's comments on the assessment report and the External Assessment Centre's responses

No factual inaccuracies in the assessment report were identified by the manufacturer.