Clinical Trials and Regulatory Science in Cardiology 16 (2016) 1–5

Contents lists available at ScienceDirect

Clinical Trials and Regulatory Science in Cardiology

journal homepage: http://www.elsevier.com/locate/ctrsc

Diagnosis of myocardial infarction and prognostic utility of high-sensitivity troponin T after isolated aortic valve replacement☆,☆☆,★

Tom K.M. Wang [a,1], Ralph A.H. Stewart [a,b,1], Tharumenthiran Ramanathan [a,1], David Choi [a,1], Greg Gamble [b,1], Peter N. Ruygrok [a,b,1], Harvey D. White [a,b,*,1]

[a] Green Lane Cardiovascular Service, Auckland City Hospital, Auckland, New Zealand
[b] Department of Medicine, University of Auckland, Auckland, New Zealand

ARTICLE INFO

Article history:
Received 7 December 2015
Accepted 25 January 2016
Available online 16 February 2016

Keywords:
Aortic valve replacement
High-sensitivity troponin
Myocardial infarction
Coronary artery bypass grafting
Mortality

ABSTRACT

Background: The Universal Definition for type 5 myocardial infarction (MI) applies to coronary artery bypass grafting (CABG), while MIs for other cardiac surgery are not specifically defined. We assessed whether elevated high-sensitivity troponin (hs-TnT), with electrocardiogram (ECG) changes and/or new wall motion abnormalities on echocardiography as defined by the Universal Definition, predicted mortality and/or morbidity after aortic valve replacement (AVR) (n = 219).

Methods: Consecutive patients with isolated AVR performed during July 2010–December 2012 and followed-up for 2.3 ± 0.8 years. Hs-TnT was measured 12–24 h post-operatively. ECG and/or echocardiographic changes with hs-TnT > 140 ng/L (10 times 99th percentile upper reference limit and > 500 ng/L (10 times the coefficient of variation of 10% for 4th generation troponin T applied to hs-TnT) were pre-specified as the criteria for MI diagnosis.

Results: There were 9.1% (20) and 3.7% (8) patients with ECG and/or echocardiographic changes and hs-TnT > 140 ng/L and hs-TnT > 500 ng/L respectively. Neither criterion was independently associated with 30-day mortality (2.7%). Hs-TnT > 500 ng/L and ECG and/or echocardiographic changes was independently associated with mortality (5.5%) during follow-up, hazards ratio 5.23, 95% confidence interval 1.09–25.2, p = 0.039. Hs-TnT per 100 ng/L as a continuous parameter was independently associated with 30-day mortality, mortality during follow-up and composite morbidity.

Conclusion: The Universal Definition of MI, using 10 times the URL for the 4th generation troponin T and 35 times the URL for hs-TnT with a cutpoint of > 500 ng/L with ECG and/or echocardiographic changes, independently predicted median term mortality after AVR. Hs-TnT as a continuous parameter was independently associated with mortality at both time points and morbidity.

1. Introduction

The 2012 Third Universal Definition defines type 5 myocardial infarction (MI) after coronary artery bypass grafting (CABG) as requiring the dual criteria of biomarker rise, preferably troponin, >10 times 99th percentile upper reference limit (URL) from a normal pre-operative level, and new signs of infarction on the electrocardiogram (ECG), echocardiogram, cardiac magnetic resonance imaging (MRI), and/or bypass graft occlusion on coronary angiography [1]. The Definition also suggests applying the above definition to other cardiac procedures, while acknowledging that biomarker rise is significantly higher for combined CABG and valve surgery than CABG alone, and with on-pump compared to off-pump CABG [1–3]. The definition is based on pathophysiological criteria and not a definition that correlates with prognosis.

Despite these recommendations, there is a paucity of literature around how to define MI for valve surgery. Studies assessing troponin levels after cardiac surgery are predominantly based on CABG, [4–7] and the few studies looking specifically at troponin levels after valve surgery have found different thresholds to those reported for CABG [8–10].

High-sensitivity troponins can detect lower troponin levels [11,12] but have not been investigated in this context. We aimed to assess the diagnostic and prognostic utility of high-sensitivity troponin T (hsTnT) after isolated aortic valve replacement (AVR) using the Universal Definition of MI.

☆ Acknowledgement of grant support and conflict of interest.
☆☆ TW, RS, TR, DC, GG and PR have no conflicts to declare.
★ HW has received research grants from Sanofi Aventis; Eli Lilly; NIH; Merck Sharpe & Dohme; Astra Zeneca; GSK; Daiichi Sankyo Pharma Development; has served on advisory boards for Astra Zeneca; and has received consultancy fees from Daiichi Sankyo Pharma Development.
* Corresponding author at: Green Lane Cardiovascular Service, Auckland City Hospital, Private Bag 92024, Victoria St West, Auckland 1142, New Zealand.
E-mail address: HarveyW@adhb.govt.nz (H.D. White).
[1] The authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

http://dx.doi.org/10.1016/j.ctrsc.2016.01.003

2. Methods

2.1. Patient cohort, clinical characteristics and outcomes

All patients undergoing isolated AVR without concomitant valve or coronary surgery at Auckland City Hospital during July 2010 to December 2012 were retrospectively identified. Patients with elevated pre-operative hsTnT levels >14 ng/mL were excluded. Clinical characteristics and outcomes were prospectively collected in computerized databases for analyses. The Society of Thoracic Surgeon's (STS) definitions were used for pre-operative characteristics [13]. The Canadian Cardiovascular Society Classification (CCS) and the New York Heart Association Functional Classification (NYHA) were used to grade angina and heart failure respectively. Valve stenosis or regurgitation needed to be at least moderate in severity. The definition of active infective endocarditis required that at the time of surgery, a course of intravenous antibiotics had yet to be commenced or completed. Renal function was calculated as the estimated glomerular filtration rate (eGFR) using the Modification of Diet in Renal Disease (MDRD) equation and the pre-operative serum creatinine measurement. EuroScore, [14] EuroScore II [15] and STS score's AVR Model [13] were calculated.

The pre-specified outcomes for analyses were mortality within 30 days, mortality during follow-up and composite morbidity, as defined by the STS score, [13] which includes permanent stroke (acute neurological deficit >24 h due to cerebral blood supply disturbance), renal failure (new dialysis requirement or increase of creatinine level to >4.0 mg/dL and >3 times last pre-operative level), prolonged ventilation >24 h, deep sternal wound infection and return to theatre for any reason. Mortality data were checked against New Zealand's National Registry up till 30 June 2014.

2.2. Troponin assays and criteria for myocardial infarction

Hs-TnT assay (Roche Elecsys) was introduced to Auckland City Hospital in July 2010, and has a 99th percentile URL of 14 ng/L [11]. The cutpoint used for the previous 4th generation troponin T with a 10% coefficient of variation (0.03 ng/ml) when applied to the hs-TnT assay is 50 ng/l [12]. Hs-TnT was routinely measured 12–24 h after surgery, and the highest level was used if measured more than once during this time. Two cutpoints of 140 ng/L and 500 ng/L were pre-specified for analyses in accordance to the above thresholds and the universal definition's recommendation of 10 times 99th percentile URL for the diagnosis of type 5 MI [1]. Hs-TnT was not routinely measured pre-operatively, and we excluded patients with a new MI diagnosis or any elevated hs-TnT > 14 ng/L measurements pre-operatively during the same admission as the AVR operation.

ECGs were routinely performed recorded multiple times pre- and post-operatively while echocardiography was performed routinely intra-operatively after aortic valve implantation as a baseline for future assessments, and repeated when clinically indicated. New Q-waves or new left bundle branch block (LBBB) on ECG, and/or new regional wall motion abnormalities on echocardiography were independently assessed by two authors (TKMW and HDW) blinded to outcomes, in accordance to the criteria of the Universal definition [1]. The prognostic utility of dual criteria of hs-TnT elevation and ECG and/or echocardiographic criteria, as well as these criteria individually, was compared.

2.3. Statistical analyses

Continuous and categorical variables are presented as mean (standard deviation) and percentage (frequency) respectively, Mann–Whitney U test and Fisher's exact test were used for univariate analyses. Survival analyses were performed with Kaplan–Meier curves and log-rank (Mantel-Cox) test. The pre-specified hs-TnT cutpoints of 140 ng/L and 500 ng/L with or without ECG and/or echocardiographic changes were used for analyses. Variables with $P < 0.10$ in univariate analyses were incorporated into multivariable analyses of outcomes, using logistic regression to calculate odds ratios (OR) or Cox proportional hazards regression used to calculate hazards ratios (HR). Each potential MI criteria was individually added to the models of post-operative outcomes to see whether they predicted these outcomes. Also receiver-operative characteristics (ROC) analysis was used to calculate c-statistic and 95% confidence interval (CI) as well as identifying the optimal cut-point with maximum sensitivity × specificity. All tests were two-tailed and $P < 0.05$ deemed statistically significant. SPSS (Version 17.0, SPSS Inc., Chicago, IL, USA) and Prism (Version 5, GraphPad Software, San Diego, CA, USA) were used for analyses. Ethics approval was obtained from, Auckland City Hospital's research office Ethics Committee.

3. Results

3.1. Baseline characteristics

A total of 219 patients underwent isolated AVR at Auckland City Hospital, New Zealand over the 2.3 year study period (386 patient years). Table 1 shows the baseline characteristics. The mean age was 67.5 ± 14.9 years and 33.3% (73) were female. Previous valve surgery and CABG had been performed in 7.3% (16) and 7.3% (16) of patients respectively. Underlying aortic valve dysfunction was isolated aortic stenosis in 67.0% (146), isolated aortic regurgitation 21.6% (47) and both in 11.5% (25). The mean EuroScore, EuroScore II and STS AVR Scores were 8.6% ± 8.1%, 3.1% ± 3.3% and 2.9% ± 2.9% respectively.

3.2. Operative outcomes

Blood cardioplegia was used for myocardial protection. There were 14.7%, 63.3% and 22.0% patients who received anterograde, retrograde and dual cardioplegia delivery routes respectively. Warm induction was given at a temperature of 32 °C in 11.9% and the remaining patients were given cold induction at a temperature of 4 °C. Secondary analyses did not identify cardioplegia variables to independently influence hs-TnT levels or adverse outcomes.

Table 2 lists operative variables and post-operative outcomes. Mechanical valves were implanted in 31.1% (68) and bioprosthetic valves in 68.9% (151). Median and lower-upper quartiles of hs-TnT were 360 (258–536) ng/L measured at 16.7 ± 5.9 h post-operatively. For the pre-specified hs-TnT cutpoints, 98.6% (216) had hs-TnT > 140 ng/L and 31.1% (68) had hs-TnT > 500 ng/L.

All 219 patients had post-operative ECGs performed with 8.7% (19) developing new Q-waves or new LBBB. Echocardiograms were performed in 31.5% (69) of patients with one showing a new regional wall motion abnormality. Therefore, 9.1% (20) patients fulfilled the ECG and/or echocardiographic criteria for diagnosis of MI. For the pre-specified hs-TnT cutpoints, 9.1% (20) had hs-TnT > 140 ng/L and ECG and/or echocardiographic criteria, while 3.7% (8) had hs-TnT > 500 ng/L and ECG and/or echocardiographic criteria.

Thirty-day mortality was 2.7% (6). Composite morbidity occurred in 20.5% (45) including post-operative stroke in 1.4% (3), prolonged ventilation >24 h 13.7% (30) and return to theatre for any cause in 6.8% (Table 2). Mean hospital stay post-operatively was 8.9 ± 5.1 days. Follow-up mortality was 5.5%.

3.3. Receiver-operating characteristic analyses

Results of ROC analyses are shown in Table 3. The dual criteria of hs-TnT as a continuous parameter and ECG and/or echocardiographic criteria detected 30-day mortality with c-statistic and 95% confidence intervals of 0.816 (0.521–1.00); superior to isolated hs-TnT or isolated ECG and/or echocardiographic criteria. The best cutpoint on the ROC curve for isolated hs-TnT rise predicting 30-day mortality was 630 ng/L with a c-statistic of 0.746 (0.523–0.969). This elevation occurred in 9.1% (20) of patients. Neither of the pre-specified cutpoints

Table 1
Baseline characteristics.

Demographics	
Age, years	67.5 (14.9)
Female	33.3% (73)
Ethnicity	
New Zealand European	75.8% (166)
Maori or Pacific	16.9% (37)
Other	7.3% (16)
Body mass index, kg/m^2	29.7 (6.2)
Body surface area, m^2	1.94 (0.26)
Presentation	
New York Heart Association Class	
1	23.7% (52)
2	48.9% (107)
3	18.7% (41)
4	8.7% (19)
Canadian Cardiovascular Society Class IV	2.3% (5)
Syncope	2.7% (6)
Critical pre-operative state	3.7% (8)
Inpatient urgent operation	46.1% (101)
Past medical history	
Previous cardiac surgery	14.6% (32)
Valve surgery	7.3% (16)
Coronary artery bypass grafting	7.3% (16)
Congestive heart failure	16.0% (35)
Myocardial infarction	8.7% (19)
Atrial fibrillation	21.5% (47)
Diabetes	21.0% (46)
Diabetes on insulin	5.0% (11)
Hypertension	54.8% (120)
Hypercholesterolaemia	67.1% (147)
Current smoker	9.1% (20)
Smoking history	54.8% (120)
Active infective endocarditis	4.6% (10)
Stroke	5.0% (11)
Extracardiac arteriopathy	6.8% (15)
Chronic pulmonary disease	17.8% (39)
Pulmonary hypertension, ≥31 mm Hg	10.5% (23)
Dialysis	2.3% (5)
Investigations	
Ejection fraction	
Normal, >50%	62.1% (136)
Mild/moderate impairment, 30–50%	33.3% (73)
Severe impairment, <30%	4.6% (10)
Aortic stenosis	78.1% (171)
Aortic regurgitation	32.9% (72)
Mitral stenosis	0.9% (2)
Mitral regurgitation	7.3% (16)
Tricuspid regurgitation	3.7% (8)
Left main artery ≥ 50% stenosis	
Main coronary vessels ≥ 50% stenosis*	2.3% (5)
0	84.5% (185)
1	8.2% (18)
2	1.4% (3)
3	5.9% (13)
Creatinine clearance, mL/min	85 (40)
Risk score	
EuroScore	8.6% (8.1%)
EuroScore II	3.1% (3.3%)
Society of Thoracic Surgeon's AVR Score	2.9% (2.9%)

All numbers are mean (standard deviation) or percentage (frequency).
* Stenoses had been previously grafted, stented or were not suitable for grafting.

Table 2
Operative variables and outcomes.

Operative variables	
Mechanical valve, %	31.1% (68)
Operation time, minutes	188 (60)
Cardiopulmonary bypass time, minutes	98 (30)
Cross-clamp time, minutes	74 (20)
High-sensitivity troponin, ng/L	360 (258–536)
ECG or echocardiographic changes	9.1% (20)
Outcomes	
Composite morbidity	20.5% (45)
Renal failure	5.9% (13)
Stroke	1.4% (3)
Deep sternal wound infection	0.9% (2)
Ventilation >24 h	13.7% (30)
Return to theatre	6.8% (15)
New atrial fibrillation	27.9% (61)
Permanent pacemaker implantation	5.9% (13)
Operation to discharge time, days	8.9 (5.1)
30-day mortality	2.7% (6)

All numbers are mean (standard deviation) or percentage (frequency).

for hs-TnT, with or without ECG and/or echocardiographic changes predicted 30-day mortality and mortality during follow-up.

Hs-TnT as a continuous parameter, or rise to >500 ng/were able to detect composite morbidity with c-statistics of 0.626 (0.528–0.724) and 0.612 (0.517–0.708), superior to dual criteria involving ECG and/or echocardiographic changes. The optimal cutpoint for hs-TnT to detect composite morbidity was 500 ng/L.

3.4. Survival

Fig. 1 shows the Kaplan–Meier survival curves over mean follow-up of 2.3 ± 0.8 years by criteria of isolated hs-TnT rise or dual ECG or echocardiographic criteria at various hs-TnT thresholds as previously defined. Log-rank test p-values and 1-year survival for each criterion are also shown. Hs-TnT > 140 ng/L and hs-TnT > 500 ng/L and other criteria were associated with higher mortality during follow-up ($P < 0.05$).

3.5. Multivariable analyses

Multivariable analyses for 30-day mortality and mortality during follow-up are presented in Table 4. Neither of the pre-specified criteria predicted 30-day mortality. Hs-TnT >500 ng/L and ECG and/or echocardiographic criteria was independently associated with mortality during follow-up HR 5.23, 95% CI 1.09–25.2, $P = 0.039$ respectively. Hs-TnT alone as a continuous parameter was independently associated with 30-day and medium-term mortality ($P = 0.034$ and $P = 0.036$). Other predictors of 30-day mortality were Class IV angina ($P = 0.036$) and atrial fibrillation ($P = 0.048$). Class IV angina ($P = 0.011$) and atrial fibrillation ($P = 0.001$) also predicted mortality during follow-up.

Table 5 lists the independent predictors of composite morbidity. Isolated troponin rise to > 500 ng/L was independently associated with composite morbidity HR 2.56, 95% CI 1.09–5.11, $P = 0.030$ as was hs-TnT as a continuous parameter ($P = 0.001$). Dual ECG and/or echocardiographic criteria were not independently associated with composite morbidity. Other predictors of composite morbidity included NYHA Class IV ($P = 0.036$), active infective endocarditis ($P = 0.003$), extra cardiac arteriopathy ($P = 0.035$) and impaired ejection fraction <45% ($P = 0.018$).

4. Discussion

This study has several important novel findings. First, hs-TnT > 500 ng/L and ECG and/or echocardiographic changes was independently associated with mortality during follow-up but not 30-day mortality. Second, hs-TnT > 140 ng/L and ECG and/or echocardiographic criteria was not associated with mortality at either time point. Third, hs-TnT alone as a continuous parameter was an independent predictor of all three pre-specified outcomes of interest (30 day mortality, mortality during follow-up and composite morbidity).

4.1. Isolated elevation of high-sensitivity troponin

Some, [8,10] but not all [9] studies have reported troponins to be independently associated with mortality and/or morbidity after AVR. Several studies have reported that post-operative troponin I or T as a single test and as a continuous parameter predicts short and long-term mortality in cardiac surgery cohorts, made up predominantly or

Table 3
Receiver-operating characteristic analyses.

Criteria	30-day mortality	Mortality during follow-up	Composite morbidity
hsTnT	0.752 (0.486–1.00)	0.615 (0.422–0.808)	0.626 (0.528–0.724)
ECG/echo criteria	0.710 (0.490–0.930)	0.584 (0.455–0.713)	0.516 (0.473–0.559)
hsTnT + ECG/echo	0.816 (0.521–1.00)	0.632 (0.427–0.838)	0.610 (0.508–0.712)
hsTnT > 140 ng/L	0.507 (0.275–0.739)	0.507 (0.341–0.674)	0.509 (0.415–0.602)
hsTnT > 500 ng/L	0.682 (0.461–0.904)	0.555 (0.383–0.727)	0.612 (0.517–0.708)
hsTnT > 630 ng/L	0.746 (0.523–0.969)	0.621 (0.443–0.799)	0.606 (0.507–0.704)
hsTnT > 140 ng/L + ECG/echo	0.710 (0.458–0.962)	0.584 (0.402–0.766)	0.516 (0.422–0.609)
hsTnT > 500 ng/L + ECG/echo	0.653 (0.388–0.917)	0.569 (0.386–0.751)	0.509 (0.603–0.415)

ECG = electrocardiogram; hsTnT = high-sensitivity troponin T.

entirely of patients undergoing CABG, and superior to other tests such as creatine kinase-MB and the ECG alone [3–7,16].

Several studies have reported varying optimal cut-points for isolated troponin rise for detecting mortality after CABG between 7.8–170 times URL [4,17–19]. One study reported an optimal cut-point for a troponin I assay in aortic or mitral valve surgery at 15.5 times URL, slightly higher than the corresponding optimal cut-point of 13 times URL for CABG in the same study [8]. We found higher hs-TnT levels post-operatively with AVR compared with isolated CABG on average (median 360 ng/L vs 339 ng/L at our centre [3]. This may reflect the presence of more left ventricular hypertrophy in aortic stenosis. However, the only independent association was hs-TnT > 500 ng/L alone predicting composite morbidity, similar to what we found in patients undergoing CABG [3].

4.2. Dual high-sensitivity troponin T and ECG and/or echocardiographic criteria

ECG and/or echocardiographic criteria alone in our AVR cohort was not independently associated with mortality or morbidity, in contrast to our findings in patients undergoing CABG [3]. Combining this with hs-TnT elevation as dual criteria, which has not been previously investigated in the context of valve surgery, added incremental predictive power for mortality as demonstrated in our ROC analysis.

Despite the above, none of the pre-specified hs-TnT thresholds as with dual criteria predicted 30-day mortality. However hs-TnT > 500 ng/L + ECG and/or echocardiographic changes predicted mortality during follow-up. This is 10 times 99th percentile URL as

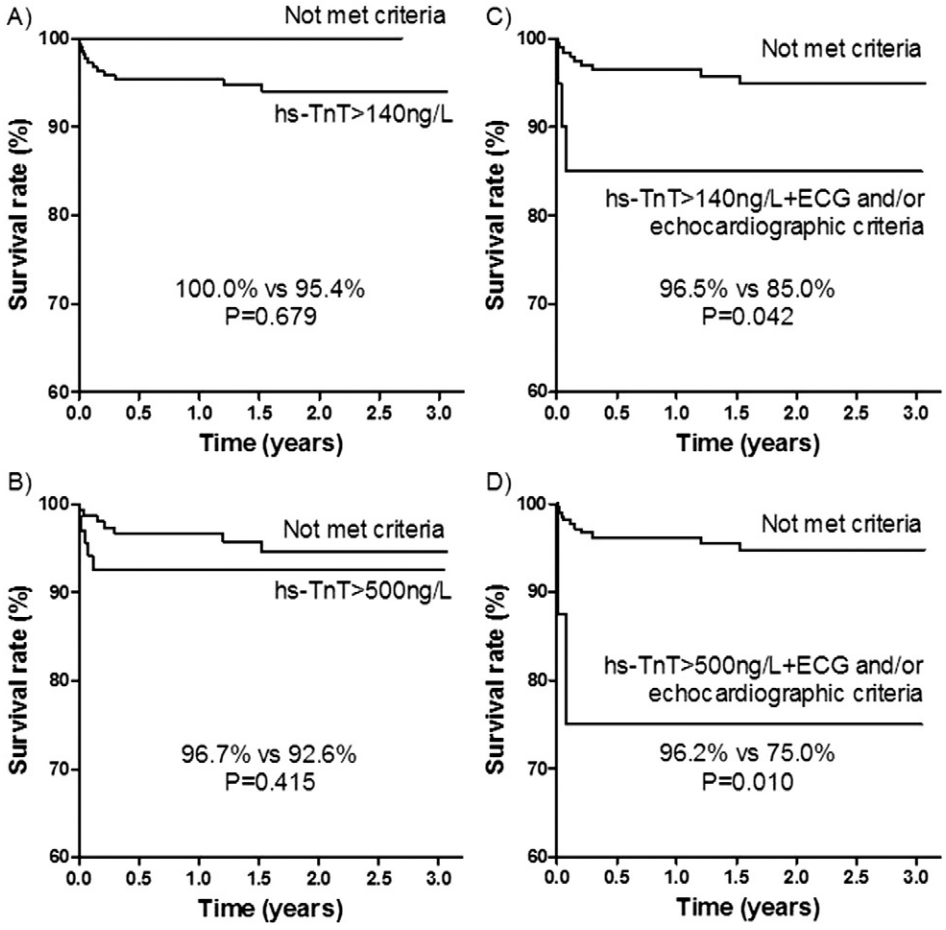

Fig. 1. Kaplan–Meier survival curves for myocardial infarction criteria a) hs-TnT > 140 ng/L, b) hs-TnT > 500 ng/L, c) hs-TnT > 140 ng/L and ECG and/or echocardiographic criteria, d) hs-TnT > 500 ng/L and ECG and/or echocardiographic criteria. Log-rank test p-values and 1-year survival are shown.

Table 4
Multivariable analyses of mortality.

Predictors	Odds/hazards ratio	95% confidence interval	P-value
30-day mortality			
Canadian Cardiovascular Society Class IV	4.80	1.11–20.8	0.036
Atrial fibrillation	4.48	1.04–19.3	0.048
No. of diseased coronary vessels	3.73	1.01–13.9	0.050
hsTnT per 100 ng/L	1.46	1.03–2.06	0.034
ECG/echo	7.76	0.68–88.7	0.099
hsTnT > 140 ng/L	–	–	0.999
hsTnT > 500 ng/L	2.94	0.329–26.28	0.335
hsTnT > 140 ng/L + ECG/echo	7.76	0.68–88.7	0.099
hsTnT > 500 ng/L + ECG/echo	6.83	0.332–140	0.043
Mortality during follow-up			
Canadian Cardiovascular Society Class IV	1.67	1.13–2.49	0.011
Atrial fibrillation	8.12	2.29–28.8	0.001
hsTnT per 100 ng/L	1.18	1.04–1.34	0.034
ECG/echo	3.43	0.892–13.2	0.073
hsTnT > 140 ng/L	–	–	0.989
hsTnT > 500 ng/L	1.08	0.307–3.82	0.902
hsTnT > 140 ng/L + ECG/echo	3.43	0.893–13.2	0.073
hsTnT > 500 ng/L + ECG/echo	5.23	1.09–25.2	0.039

ECG = electrocardiogram; hsTnT = high-sensitivity troponin T.

defined in the Universal Definition, [1] for the 4th generation troponin T and 35 times the URL for hs-TnT.

4.3. Clinical implications

The results of the study suggest that in patients undergoing AVR, hs-TnT should be measured routinely pre-operatively and post-operatively at 12–24 h in patients without recent MI or elevated preoperative levels. ECGs should be routinely performed pre-operatively and post-operatively and echocardiography when clinically indicated. Future studies are required to assess the diagnoses of MI when pre-operative levels of hsTnT are elevated, but stable or falling [1] and to confirm optimal cutpoints of hs-TnT with or without ECG/echocardiographic criteria in larger prospective cohort. Interventions that may reduce the frequency and/or worse prognosis of patients with peri-operative MI will also need to be tested.

4.4. Limitations

This is a single-centre, retrospective observational study with 2.3 year follow-up. The moderate cohort size meant that the numbers of adverse events limits the power for analyses. Patients with a recent MI were excluded as elevated troponin levels would confound the interpretation of the post-operative levels. Also we excluded patients with pre-operative hsTnT levels > 14 ng/mL. Echocardiography was performed when clinically indicated and routinely in a proportion of patients (31.5%) when logistically possible. Other forms of cardiac imaging were not performed routinely.

Table 5
Multivariable analyses of composite morbidity.

Predictors	Odds ratio	95% confidence interval	P-value
NYHA IV	3.39	1.08–10.6	0.036
Active infectious endocarditis	8.80	2.05–37.8	0.003
Extracardiac arteriopathy	3.69	1.10–12.4	0.035
Ejection fraction <45%	2.98	1.21–7.35	0.018
hsTnT per 100 ng/L	1.15	1.06–1.26	0.001
ECG/echo	1.89	0.467–7.60	0.373
hsTnT > 140 ng/L	–	–	0.999
hsTnT > 500 ng/L	2.56	1.09–5.11	0.030
hsTnT 140 ng/L + ECG/echo	1.88	0.466–7.59	0.375
hsTnT 500 ng/L + ECG/echo	3.24	0.340–30.8	0.307

ECG = electrocardiogram; hsTnT = high-sensitivity troponin T. NYHA = New York Heart Association Functional Classification.

5. Conclusion

This study shows that the use of hs-TnT with a cutpoint of > 500 ng/L (10 times coefficient of variation of 10% for 4th generation troponin T applied to hs-TnT and 35 times 99th percentile URL for hs-TnT) with ECG and/or echocardiographic changes predicts medium-term mortality after AVR. Hs-TnT as a continuous parameter was also independently associated with 30-day mortality, mortality during follow-up, and composite morbidity.

Acknowledgements

We would like to thank all our colleagues affiliated with the Green Lane Cardiovascular Service for their contributions and support and Charlene Nell, Desktop Support Administrator, for excellent secretarial assistance.

References

[1] Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. Eur Heart J 2012;33:2551–67.
[2] Selvanayagam JB, Petersen SE, Francis JM, et al. Effects of off-pump versus on-pump coronary surgery on reversible and irreversible myocardial injury: a randomized trial using cardiovascular magnetic resonance imaging and biochemical markers. Circulation 2004;109:345–50.
[3] Wang TK, Stewart RA, Ramanathan T, et al. Diagnosis of MI after CABG with high-sensitivity troponin T and new ECG or echocardiogram changes: relationship with mortality and validation of the Universal definition of MI. Eur Heart J Acute Cardiovasc Care 2013;2:323–33.
[4] Croal BL, Hillis GS, Gibson PH, et al. Relationship between postoperative cardiac troponin I levels and outcome of cardiac surgery. Circulation 2006;114:1468–75.
[5] Domanski MJ, Mahaffey K, Hasselblad V, et al. Association of myocardial enzyme elevation and survival following coronary artery bypass graft surgery. J Am Med Assoc 2011;305:585–91.
[6] Januzzi JL, Lewandrowski K, MacGillivray TE, et al. A comparison of cardiac troponin T and creatine kinase-MB for patient evaluation after cardiac surgery. J Am Coll Cardiol 2002;39:1518–23.
[7] Lurati Buse GA, Koller MT, Grapow M, et al. The prognostic value of troponin release after adult cardiac surgery - a meta-analysis. Eur J Cardiothorac Surg 2010;37:399–406.
[8] Fellahi JL, Hedoire F, Le Manach Y, et al. Determination of the threshold of cardiac troponin I associated with an adverse postoperative outcome after cardiac surgery: a comparative study between coronary artery bypass graft, valve surgery, and combined cardiac surgery. Crit Care 2007;11:R106.
[9] Piekarska ML, Szurlej B, Latusek T, Wdowik G, Deja MA. Postoperative serum troponin T concentration in patients undergoing aortic valve replacement does not predict early postoperative outcome. Kardiol Pol 2013;71:1237–44.
[10] Ponce G, Romero JL, Hernandez G, et al. The non Q wave myocardial infarction in conventional valvular surgery. Diagnosis with cardiac troponin I. Rev Esp Cardiol 2001;54:1175–82.
[11] Apple FS, Collinson PO. Analytical characteristics of high-sensitivity cardiac troponin assays. Clin Chem 2012;58:54–61.
[12] Giannitsis E, Kurz K, Hallermayer K, et al. Analytical validation of a high-sensitivity cardiac troponin T assay. Clin Chem 2010;56:254–61.
[13] Shahian DM, O'Brien SM, Filardo G, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 1–coronary artery bypass grafting surgery. Ann Thorac Surg 2009;88:S2–22.
[14] Nashef SA, Roques F, Michel P, et al. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg 1999;16:9–13.
[15] Nashef SA, Roques F, Sharples LD, et al. EuroSCORE II. Eur J Cardiothorac Surg 2012;41:734–44 (discussion 744-735).
[16] Soraas CL, Friis C, Engebretsen KV, et al. Troponin T is a better predictor than creatine kinase-MB of long-term mortality after coronary artery bypass graft surgery. Am Heart J 2012;164:779–85.
[17] Carrier M, Pellerin M, Perrault L, Solymoss BC, Pelletier LC. Troponin levels in patients with myocardial infarction after coronary artery bypass grafting. Ann Thorac Surg 2000;69:435–40.
[18] Lim CC, Cuculi F, van Gaal WJ, et al. Early diagnosis of perioperative myocardial infarction after coronary bypass grafting: a study using biomarkers and cardiac magnetic resonance imaging. Ann Thorac Surg 2011;92:2046–53.
[19] Mohammed AA, Agnihotri AK, van Kimmenade RR, et al. Prospective, comprehensive assessment of cardiac troponin T testing after coronary artery bypass graft surgery. Circulation 2009;120:843–50.