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ORIGINAL ARTICLE

Early Discharge From Intensive Care After Cardiac Surgery is Feasible With an Adequate Fast Track, Stepdown Unit: Waikato Experience

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Background Enhanced recovery programs within cardiothoracic surgery are a well described benefit to patient post-operative outcomes. We describe our Australasian unit's experience of a day zero discharge enhanced recovery unit from the intensive care department.

Methods A retrospective study was conducted on a prospectively maintained database at Waikato Cardiothoracic Unit from September 2014 till October 2017 with 1,739 patients undergoing cardiac surgery. Twenty-two (22) patients were excluded as deaths either intraoperative or in the intensive care unit (ICU) and therefore never discharged. Total population of the study was 1,717 patients. The primary endpoint of this study was to determine if there is no survival disadvantage for the day zero discharge unit compared to standard treatment in ICU at follow-up. The secondary endpoint of the study was to highlight the association between pre and postoperative variables and the impact on discharge from the ICU.

Results One hundred sixty-eight (168) patients were discharged to the enhanced recovery unit (ERU) day zero. Mean number of hours spent in ICU for the day zero cohort was 7.18 (±1.59. Mean Age 62.5 (±11.22), M:F 4.25:1. Patients were more likely to be discharged day zero if they had a lower EuroSCORE II 1.57 (±1.67) and lower preoperative creatinine 89.4 (±27.5). Those admitted to the ERU on day zero postoperatively were more likely to be discharged with a lower creatinine level, a higher haemoglobin level and have less readmissions per 30 days ($p < 0.05$). Survival analysis demonstrated that the patients who were discharged early from ICU had significantly better follow-up survival compared to those who were discharged after 24 hours ($p < 0.05$).

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Conclusions A fast track unit increases the efficiency of an ICU and cardiac surgical department. With the advancements of cardiac surgery a higher number of patients will be suitable for a fast track method. Our unit has demonstrated that a day zero fast track unit in New Zealand can perform with adequate patient safety with no increased risk of mortality and with low rates of failure of the day zero discharge fast track therapy.

Keywords Enhanced recovery after surgery • Cardiac surgery • Intensive care • Fast track • Survival

Introduction

A well-documented treatment practise is enhanced recovery after surgery (ERAS) [1]. This has been extrapolated to cardiothoracic surgery where there are wide ranging postoperative protocols with units utilising a stepdown unit from an intensive care unit (ICU) ranging from on table extubation and unit transfer, to transfer to ICU and early day zero discharge. The utilisation of a fast track discharge is unquestioned as to its efficacy on productivity and efficiency of the cardiothoracic department [2]. However, it is crucial to ascertain the safety of such a process on patient outcomes.

We describe the first experience in the literature of a fast track model within cardiothoracic surgery in New Zealand. This was commenced in 2014 with the purpose to decrease the length of stay for patients in the ICU and to increase bed space availability in the ICU. Patients who are discharged within 10 hours of surgery to the unit are classified as a day zero-unit discharge.

The goal of this study was to evaluate the safety of the day zero enhanced recovery unit (ERU). The primary endpoint of this study was to determine if there is no survival disadvantage for the day zero discharge unit compared to standard treatment in ICU at follow-up. The secondary endpoint of the study was to highlight the association between pre and postoperative variables and the impact on discharge from the ICU.

Methods

A retrospective study of a prospectively maintained database of patients who underwent cardiac surgery from 29 September 2014 until 13 October 2017 at Waikato Hospital was conducted. The records were collected from the unit's electronic database. This resulted in a total population of 1,739 of which 22 were excluded as they were either intraoperative or postoperative deaths in the ICU and therefore never discharged from the ICU. This resulted in a total population of 1,717 for analysis. Follow-up death data was received from the chronic disease database which is updated monthly by the associated government agency. This data was acquired on 14 December 2017 and is the endpoint for mortality analysis. Pre and postoperative variables were obtained from the electronic database with new onset atrial fibrillation (AF) requiring treatment, and stroke defined as obtained in hospital. Readmissions to the ICU and hospital within 30 days were assessed from the electronic cardiothoracic database and cross-referenced with the hospital database for accuracy.

Statistical Analysis

Categorical data are summarised as frequencies and percentages and continuous variables as means ± standard deviations or, when their distribution was non parametric, as medians and 25th and 75th percentiles. Differences between groups were detected using the $\chi 2$ test or Fisher's exact test for categorical variables and unpaired t-test and Kruskal

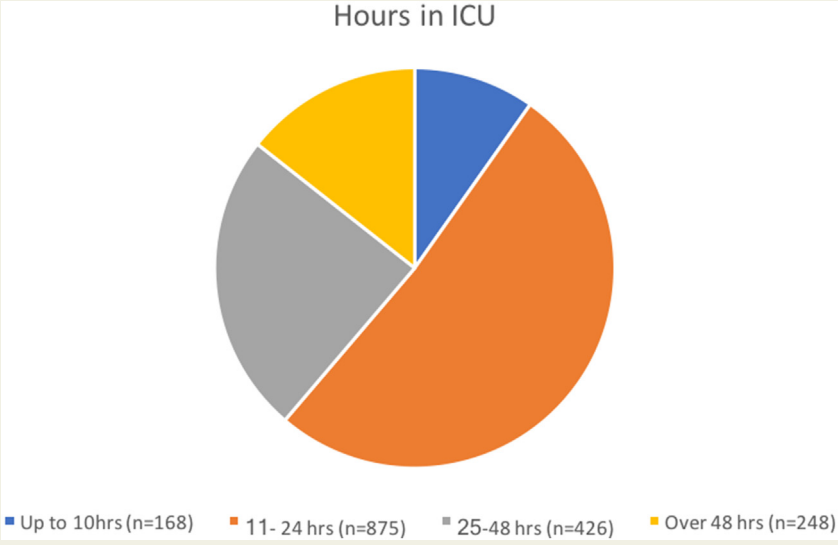


Figure 1 Distribution of discharge from ICU (intensive care unit) in hours.

Table 1 Preoperative demographics day 0 (<10 hours) v > day 1 (>10 hours) in ICU.

Parameter	Day 0 (<10 Hours) n = 168	> Day 1 (>10 Hours) n = 1,549	P-value
Age			
Mean	62.5	65.3	<0.05
Median	64	67	
Sex			
Male	136 (81%)	1,162 (75%)	<0.05
Female	32 (19%)	387 (25%)	
NYHA Score			
Mean	1.7	1.88	
Median	2	2	
EuroSCORE II			
Mean	1.57	3.07	<0.05
Median	1.1	1.65	
Diabetes			
	40 (23.8%)	318 (21%)	
CCF			
	14 (8.3%)	265 (17%)	<0.05
Hypertension			
	115 (68.4%)	1,121 (72.3%)	
PVD			
	9 (5.35%)	128 (8.2%)	<0.05
Previous smoking history			
	82 (48.8%)	906 (58.4%)	<0.05
Preoperative rhythm			
SR	145 (86%)	1,254 (81%)	
AF	20 (12%)	254 (16%)	
Other	3 (2%)	41 (3%)	
Ejection Fraction (EF)			
Mean	60.96	56.8	<0.05
Median	65	63	
Preoperative haemoglobin (Hb)			
Mean	139.04	136.1	
Median	140	138	
Preoperative creatinine			
Mean	89.4	99.7	<0.05
Median	84	87	

Abbreviations: NYHA, New York Heart Association Score; CCF, congestive cardiac failure; PVD, peripheral vascular disease; SR, sinus rhythm; AF, atrial fibrillation; ICU, intensive care unit.

Table 2 Operation stratification for day 0 (<10 hours) v > day 1 (>10 hours) in ICU.

Operation	Day 0 (<10 Hours) n = 168	> Day 1 (>10 Hours) n = 1,549	Total
CABG	108 (64.2%)	840 (54.2%)	948
Single Valve	39 (23.2%)	413 (26.7%)	452
Valve + CABG	11 (6.5%)	153 (9.9%)	164
Multiple Valve	2 (1.3%)	17 (1%)	19
Aortic	5 (2.9%)	98 (6.3%)	103
Other	3 (1.9%)	28 (1.9%)	31

Abbreviations: CABG, coronary artery bypass grafting.

Table 3 Postoperative demographics for day 0 (<10 hours) v > day 1 (>10 hours) in ICU.

Parameter	Day 0 (<10 Hours) n = 168	> Day 1 (>10 Hours) n = 1,549	P-value
Hours ICU			
Mean	7.18	37.6	<0.05
Median	7	24	
Intubation time			
	3.46	8.91	<0.05
	3	7	
Length of stay hospital			
	5.9	7.6	<0.05
	5	6	
Readmitted to hospital			
	9 (5%)	183 (11.8%)	
30-Day mortality			
	2 (1.2%)	36 (2.3%)	
Readmitted to ICU 30 Days			
	2 (1.19%)	14 (0.9%)	
Stroke			
	1 (0.59%)	24 (1.5%)	
New onset AF requiring treatment			
	25 (14.8%)	351 (22.6%)	<0.05
Discharge Hb			
Mean	101.1	89.9	<0.05
Median	105	96	
Discharge creatinine			
Mean	84.3	93.9	<0.05
Median	79	81	
Rhythm discharge			
SR	151 (89.9%)	1,376 (88.8%)	
AF	16 (9.5%)	139 (8.9%)	
Other	1 (0.59%)	34 (2.19%)	

Abbreviations: SR, sinus rhythm; AF, atrial fibrillation; ICU, intensive care unit.

Wallis test or the Mann–Whitney U-test for continuous variables, as appropriate. Event rates ± one standard error were estimated using the Kaplan–Meier method. Bonferroni correction was used for significant data. All statistical analysis was performed using SPSS 25 software (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA) with $p < 0.05$ as significant. Multiple ordinal logistic regression analysis was used to test the univariate variables against the

Table 4 Univariate factors and their significance in patients who were discharged early from ICU.

Univariate factors versus early discharge from ICU	P-value
Age	0.004
EuroSCORE II	0.0005
Preoperative haemoglobin	0.004
Postoperative haemoglobin	0.0005
Preoperative creatinine	0.0005
Postoperative creatinine	0.314
Ejection fraction	0.05

Abbreviation: ICU, intensive care unit.

Table 5 Multivariate factors and the odds ratio along with significance.

Model	Odds Ratio	Significance
EuroSCORE II	1.2 (1.01–1.23)	0.0005
Preop creatinine	1.1 (1.0–1.18)	0.012
Postop haemoglobin	1.1 (0.98–1.21)	0.0005
Postop creatinine	1.1 (0.989–1.183)	0.042
Type of operation - CABG	2.44 (1.5–3.92)	0.0005

Abbreviations: CABG, coronary artery bypass grafting.

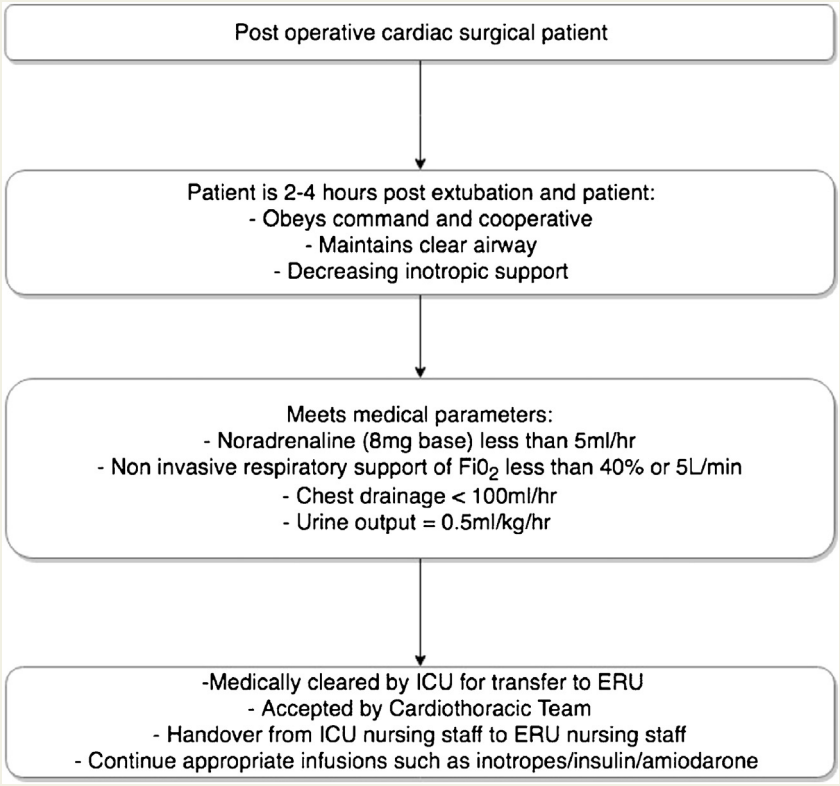


Figure 2 Discharge algorithm for patients from the ICU (intensive care unit) day zero after cardiac surgery.

dependent variable ''discharge from ICU in days''. All univariate variables below 0.05 were included in the multivariate analysis. Homogeneity and collinearity were estimated for the regression process.

Results

Over the 3-year period there was a total of 1,717 patients discharged from the ICU. There were 168 (9.8%) patients who were discharged the same day from ICU to the ERU after cardiac surgery with 1,549 discharged after day zero. The majority of patients were discharged between 11–24 hours (n = 875, 51.5%) and is demonstrated in Figure 1.

The patient demographics between the cohort discharged on day zero and the cohort discharged after day zero is demonstrated in Table 1.

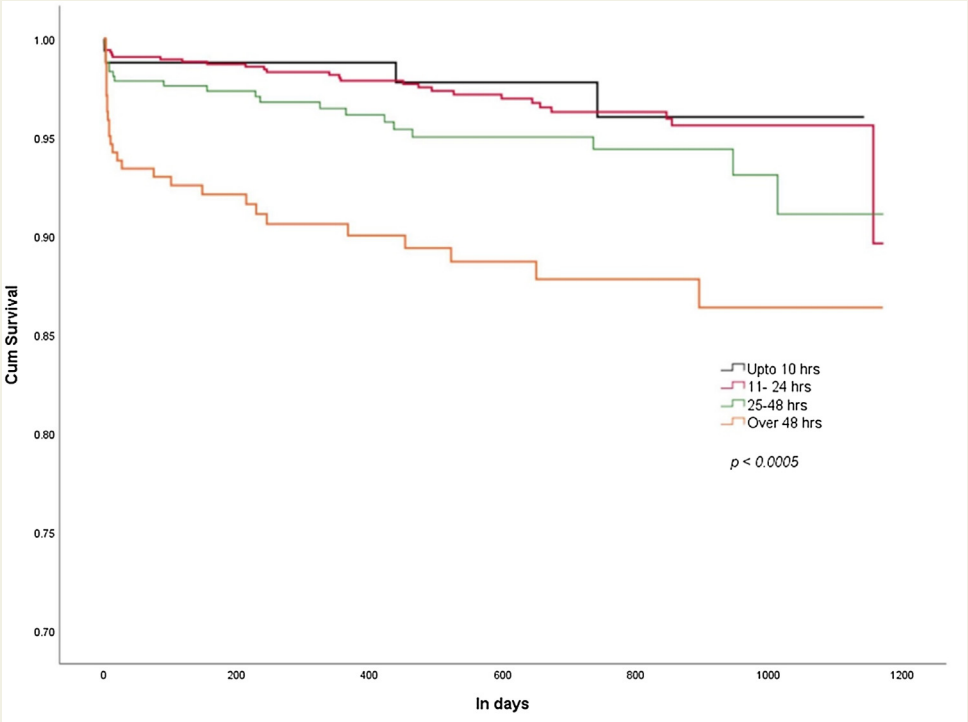
The diversity of operation type is presented in Table 2. The majority of day zero patients underwent coronary artery bypass graft (CABG). As expected, the degree of complexity of operation increased in the cohort who were in ICU for longer than day zero. This is seen in the rise of combination and aortic surgical numbers.

The postoperative demographics of the two patient cohorts are demonstrated in Table 3. The duration of stay within hospital was shorter in the day zero cohort with a mean of 5.9 days. In terms of readmission to ICU, there were two patients in the day zero cohort (1.19%) and 14 in the longer than day zero cohort. The two patients were readmitted to ICU for bleeding post pacing wire removal and for a non-cardiac cause respectively. There was a total of 192 readmissions to hospital within 30 days with nine patients in the day zero cohort and 183 in the longer than day zero cohort respectively. There were two mortalities within 30 days for the day zero cohort and 36 within the longer than day zero cohort. The discharge haemoglobin was higher and the discharge creatinine was lower in the day zero cohort when compared with the longer than day zero cohort.

Table 4 demonstrates the univariate factors and the duration of ICU stay. Due to the wide range of disease processes and uncommon procedures, the 27 patients in the Other cohort were excluded from this statistical analysis. These showed that the patient's age, EuroSCORE II, preoperative haemoglobin, preoperative creatinine, preoperative ejection fraction and postoperative haemoglobin were significant factors in determining the early discharge.

Demonstrated in Table 5, multivariate analysis using ordinal logistic regression suggested that EuroSCORE II, pre and postoperative creatinine and postoperative haemoglobin were variables impacting early ICU transfer. Along with this, patients undergoing an operation involving only CABG were significantly more likely to be discharged from ICU on day zero.

Follow-up mortality was undertaken at a mean of 624.98 days (± 319.68) with 46 deaths in total identified at a



Numbers at Risk						
Group: Upto 10 hrs						
164	141	102	74	48	18	0
Group: 11-24 hrs						
861	763	631	468	321	154	0
Group: 25-48 hrs						
419	350	276	197	132	52	0
Group: Over 48 hrs						
242	189	149	109	73	35	0

Figure 3 Kaplan-Meier curve showing total population follow up mortality in the different ICU (intensive care unit) discharge groups.

mean of 438 days (± 269). For all cause follow-up mortality, there were two deaths in the day zero cohort and the remaining 44 deaths in the cohort discharged from ICU after day zero. Due to the wide range of disease processes and uncommon procedures, the 27 patients in the Other cohort were excluded from this statistical analysis. Survival analysis demonstrated that the patients who were discharged early from ICU had significantly better long-term survival compared to those who were discharged after 24 hours, the worst survival was that for those who were discharged after 48 hours (Figure 3). This is to be expected as the cohort discharged early from ICU were younger and had a lower EuroSCORE II. Since CABG was the most commonly performed operation, we investigated the follow-up mortality of patients undergoing isolated CABG and the ICU discharge cohorts. This showed that late discharges from ICU post CABG fared significantly poorly with significantly reduced survival (Figure 4).

Discussion

A key element within modern medicine is the ability to improve upon known and established medical therapies with increased accuracy, decreased expenditure and less time spent in hospital for the patient. A stepdown fast track unit within cardiothoracic surgery is designed to fit that model.

This prospectively collected, retrospectively analysed study has demonstrated that, in our New Zealand cohort, discharge to a stepdown, day zero cardiothoracic unit has no increased mortality risk. This unit has five beds, staffed with specialised nursing staff and 24-hour coverage by the cardiothoracic unit. Facilities include inotropic support and non-invasive ventilation support at a cut-off of FiO_2 of 40%. The criteria for the discharge of cardiac patients on day zero from the ICU is demonstrated in Figure 2.

This stepdown, day zero unit differs slightly to other fast track units in contemporary literature, as those patients have no initial time in an ICU [9]. By utilising the ICU for up to 10 hours, this ensures stabilisation of the patient as well as adequate monitoring and risk stratification for discharge to the day zero unit. It is this slight variant that may explain our low rate of readmission to the ICU compared to the admission to ICU rates from other fast track units. Other units which transfer from theatre to a fast track unit describe a fast track failure of 11% [9] whilst other units which employ an

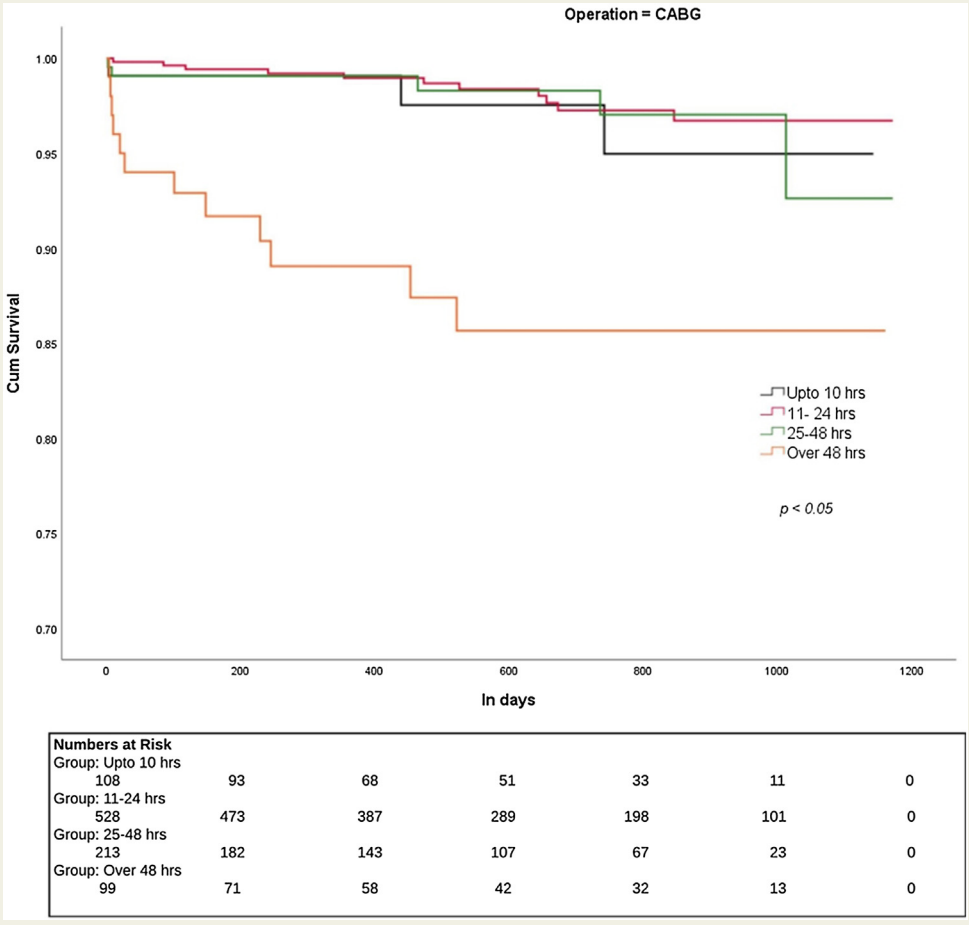


Figure 4 Kaplan-Meier curve showing CABG follow up mortality in the different ICU discharge groups. Abbreviations: CABG, coronary artery bypass grafting; ICU, intensive care unit.

ICU before transfer to fast track have described readmission rates of 2.7% [3], 3.3% [5] and 3.6% [6]. Our unit's results of utilising the ICU before transfer to the ERU demonstrate a readmission rate to ICU of 1.19% for those discharged on day zero.

The key component to the utilisation of the day zero unit is to highlight those patients who would be appropriate in the preoperative planning stage. This will allow for numerous flow-on effects for the cardiothoracic unit. Firstly, it will allow efficient planning for the surgical operating list. Secondly, it will allow the intensive care unit to appropriately plan and anticipate bed availability for postoperative management. Health care and cost benefit is an important concept within the current health system. By decreasing patient time in the ICU and increasing bed space availability, it is a cost effective system with no detriment to patient safety. Units have described a patient flow increase of approximately 15% in the ICU with the introduction of a fast track unit [4].

The crux of the utilisation of a day zero unit is the identification of those patients who would be most appropriate for early ICU discharge. Our model does have clinician based clinical assessment and this clinician dependent assessment has inherent operator bias. This has prompted other units to adopt risk prediction models to accurately identify those preoperative or postoperative risk factors. Within Australia and New Zealand, premature first discharges lead to 10% of all unplanned readmissions to the ICU [8] Furthermore, as mentioned in other units' experiences, the definition in cardiothoracic units of fit for fast track is often dependent on clinician treatment threshold [6]. Therefore, there has been a development of risk score profiling in order to further safely stratify patients into a fast track care model. This was first described by Constantinides et al. [7] and further extrapolated by Lee A et al. [6]. The variable risk factors in the risk profile include redo operations, extra cardiac arteriopathy, preoperative intra-aortic balloon pumping, serum creatinine, urgent/emergency surgery, complex surgery, recent acute coronary syndrome and the associated left ventricular function. As noted by Lee et al. [6] there are limitations with such risk models and, ideally, an impact study is required as well as a multi-centre trial, preferably multinational, in order to verify the risk model with varying populations. Bainbridge and Cheng [10] have further stated with the advancement of cardiac surgery that more patients will be suitable for a fast track method due to shorter cardiopulmonary bypass times and less invasive procedures.

Another element to the benefits of a cardiothoracic step-down unit is the ability for ward based nursing staff to be up-skilled in the acute based medicine of cardiothoracic surgery. This enables sub specialisation in nursing into a ward based, critical care environment. These nursing staff are expected to be able to care for patients with invasive monitoring, administer acute based medications as well as being trained in acute cardiothoracic advanced life support.

Conclusions

A fast track unit increases the efficiency of an ICU and cardiac surgical department. With the advancements of cardiac surgery a higher number of patients will be suitable for a fast track method. Our unit has demonstrated that a day zero fast track unit in New Zealand can perform with adequate patient safety with no increased risk of mortality and with low rates of failure of the day zero discharge fast track therapy.

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