1. Article Title

A cardio-geriatric model of care in acute heart failure: initial experience of a multidisciplinary approach in complex elderly patients.

2. Article Short title A cardio-geriatric model of HF care.

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Heart failure (HF), characterized by high morbidity, mortality and recurrent hospitalizations and is increasingly a management issue among patients with advanced age and multi-morbidity (1) (2). Hospitals may need to adapt their methods of HF care delivery to address the challenges posed by these changing demographics.

Incident hospital readmission is commonly used as an index of the quality of care provision, where the care provided by a health care organisation is considered responsible for the patient

outcomes in the post-discharge period (3). In addition to the documented benefit of evidence-based management of chronic HF (4), various overlapping care strategies employed during the phase of transition from hospital to community may be associated with reduced readmissions, as we identified in a recent systematic review: (i) the presence of a dedicated HF medical and nursing team, (ii) inpatient and outpatient medical care involving a cardiologist or HF specialist, (iii) early review in a dedicated HF clinic and (iv) the presence of a quality improvement program specific to HF care (5). We reasoned that geriatric speciality input in the acute period would further address the care needs of patients hospitalized with decompensated HF and proposed a system-wide practice change targeting those 65 years of age and over.

The primary hypothesis tested was that an inter-disciplinary model of acute and transitional care designed to optimise the care of complex elderly patients with HF, would result in a reduced rate of all-cause readmission at 30-days from the index hospitalisation, when compared to a cohort of historical controls. Secondary hypotheses evaluated effects on length of stay for the inpatient episode, as well as 12-month all-cause readmission, HF-specific readmission at 30-days and 12-months and all-cause mortality at 30-days and 12-months.

The retrospective cohort were HF patients admitted between January 2013 and January 2014, before the introduction of the cardio-geriatric HF service model in February 2014. The prospective cohort was comprised of all patients admitted under the “cardio-geriatric” HF unit between August 2014 and August 2015, after a 6 month lead-in period to allow for systemic learning effects. This model of care was introduced at a single metropolitan centre, providing care for the target group during the inpatient episode with collaboration between consultant cardiologists (7 days per week), HF specialist nurses (5 days per week) and geriatricians (5 days per week). HF nurses coordinated transitional care, integrating nurse-lead patient education and

clinical follow-up. Given the relative stability of practice guidelines over the study period, this system change enabled a pseudo-experimental comparison with the pre-existing standard of care of hospitalized HF, which, was coordinated by general physicians (2-3 days per week).

The retrospective cohort was identified from an administrative dataset via primary diagnosis ICD10-AM codes, specifying congestive heart failure, left ventricular failure and heart failure unspecified (codes I500, I501 and I509, respectively). The prospective cohort were all unique consecutive HF admissions under the cardiogeriatric unit in the time period. For both groups, inclusion required age >65 years old with definite HF according to the Boston Criteria (6). Patients were excluded if they had a haemoglobin of <80g/L, an estimated glomerular filtration rate of $\leq 15 \text{ mL/min/1.73cm}^2$, severe pneumonia, Child Pugh C liver cirrhosis, type 2 respiratory failure, advanced dementia, advanced malignancy, an acute coronary syndrome or severe aortic stenosis. Individuals who appeared in both cohorts were excluded from the prospective group. Additional clinical data were collected from the electronic medical record, readmission data was collected via a state-wide administrative dataset, allowing capture of rehospitalisation events occurring outside the primary hospital network. Mortality data was obtained via de-identified data linkage, with reference to the Australian National Death Index (7).

Approval for the study was provided from the Western Health Office for Research, Melbourne, Australia (LNR/14/WH/13). The study complied with the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines.

As per Figure 1, the prospective group included a total of 207 patients and the historical control group included 272 patients, after all exclusions were applied. Of the historical controls, 71 had

been managed by the cardiology unit, with the remainder being admitted under non-cardiology units.

As presented in Table 1, baseline demographics were well balanced between the prospective and historical control group, with an advanced median age and a high burden of multi-morbidity. The prospective group also included more patients with a higher frequency of documented HFrEF. Assessment of ejection fraction was only completed in 40% of the retrospective cohort. With respect to medications at discharge, the use of evidence-based use of beta-adrenergic receptor antagonists was greater in the prospective group. Increased use of direct oral anticoagulants (DOACs) in the prospective group was reflective of the timing of regulatory approval and adoption in Australia. Those admitted in the prospective group were more likely to undergo transthoracic echocardiography as seen in Table 2. Those in the prospective group were more likely to be referred to subacute rehabilitation following acute hospitalisation than those in the control group (14% versus 7%, $p < 0.01$).

The primary outcome variable of incident all-cause hospital readmission at 30 days was observed at a similar rate in the prospective cohort and historical controls (25.6% versus 21.7%, $p = 0.33$). The median length of stay was slightly longer in the prospective group [4 days (interquartile range 2-7 days), versus 4 (2-6) days, $p = 0.04$]. The 12-month all-cause readmission rate had no statistically significant between-group difference (66.7% versus 69.1%, $p = 1.0$). HF-specific readmission exhibited a trend towards a lower rate at 30 days in the prospective group (9.2% versus 14.7%, $p = 0.07$). All-cause mortality was not significantly different between groups at 30 days (4.4 % versus 5.2%, $p = 0.830$) and 12 months (22.2 % versus 23.9%, $p = 0.743$). A heavily skewed distribution of hospital utilization was observed in each group. Within 12 months, the median number of all-cause readmissions was 1 (0, 11) in the

prospective cohort, versus 1 (0, 11) in the historical controls ($p = 0.50$); the median number of days spent in hospital within 12 months from the index hospital episode were 5 IQR (0,132) and 4 (IQR 0,136), respectively ($p = 0.56$).

1 Discussion

Despite demonstrably intensified management in both the cardiology and geriatric domains, this study did not demonstrate a positive effect on the primary outcome of all cause readmissions at 30 days. Co-management by both a cardiologist and a geriatrician, with greater access to inpatient transthoracic echocardiography, a trend towards increased use of cardiac medications and greater referral to subacute care where rehabilitation was required, no difference was detected in readmissions or death. The retrospective nature of the comparison did not allow for the collection of frailty, functional limitation or cognitive impairment, which constitute key elements within a geriatric population. The prospective group did have a higher proportion of HFrEF, which is a known predictor of hospital readmission, although there was less overall characterization of LVEF in the retrospective cohort. One hypothesis that may be suggested, is that under this model, elderly patients with a greater known risk of re-hospitalisation were managed without an excess of early readmission.

Exploratory analysis suggested a trend towards reduced 30-day incidence of HF-specific readmission in the cardio-geriatric group ($p = 0.07$), it may be postulated that the intervention was more effective at preventing early recurrence of congestion, without a net change in re-hospitalisation.

This study compared two groups of elderly, highly comorbid patients, with a high prevalence of HFpEF, which reflects real world practice (1). In both groups length of stay and readmission rates were consistent with international best practice where further improvement may not be feasible within the current paradigm. If multiple different interventions have not improved the readmission rate, it is possible that a ceiling effect exists for this elderly group and that readmission rates cannot be improved under the available paradigms of intervention. The readmission rates among the elderly may be comparable to those found in the young, but they not be a reasonable measure to compare outcomes in these disparate groups, especially as the elderly heart failure groups are highly comorbid (8, 9). One newer paradigm is the concept of 'post-hospital syndrome', in which patients remain at an elevated readmission risk, due to an acquired transient period of vulnerability (10). Another paradigm shift could be a focus of the 'super-users' within a group, rather than common patient. The results of length of stay, readmission and number of nights in hospital showed that the median was low with a long tail to the right, meaning a small number of users skewed the data. Perhaps there is a more vulnerable group who would benefit from a tailored or personalised solution rather than a group intervention.

The pseudo-experimental design is the major limitation of this study with the two groups not perfectly matched allowing for possible other confounders. The utilization of state wide administrative data sets and national death index ensured accurate capture of the complex interplay between length of stay, readmission and death (11), which increases its validity to different healthcare systems (12). Other outcomes may be more relevant to patients in this elderly cohort such as, home time over one year (13).

Despite a trend in reducing heart failure readmissions, there was no overall difference and the trend was lost in all cause readmission. Perhaps the effect of intensifying treatment of heart

failure comes at the expense of other organ systems or increases the incidence of other illnesses. Whilst the primary outcome does not support the utilisation of routine geriatric medical evaluation, the argument for collaboration remains a strong one, which is worthy of future study.

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Tables

Table 1: Study population baseline characteristics			
	Control (n=272)	Prospective (n=207)	P-value
Age (median, IQR)	80 (74-86)	81 (75-86)	0.70
Female (n, %)	138 (51)	106 (51)	0.93
Comorbidities (n, %)			
Ischaemic heart disease	126 (46)	126 (61)	<0.01
COPD	83 (31)	62 (30)	0.92
Diabetes	115 (42)	93 (45)	0.58
Cerebrovascular disease	2 (1)	55 (27)	<0.01
Atrial fibrillation	NA	124 (60)	NA
Peripheral vascular disease	23 (8)	27 (13)	0.13
Hypertension	250 (92)	170 (82)	<0.01
History of malignancy	7 (3)	31 (15)	<0.01
Chronic kidney disease class 1, 2	109 (40)	97 (47)	0.16
Chronic kidney disease class 3	118 (43)	88 (43)	0.85
Chronic kidney disease class 4	43 (16)	22 (11)	0.11
NYHA class 1	16 (6)	10 (5)	0.69
NYHA class 2	118 (43)	74 (36)	0.11
NYHA class 3	129 (47)	105 (51)	0.52
NYHA class 4	10 (4)	18 (9)	0.03
CCI (median, IQR)	4 (3-6)	4 (3-7)	0.23
TTE +/- 6 months from admission (n, %)	109 (40)	177 (86)	<0.01
LVEF >40% (HFpEF)	73 (67)	95 (54)	0.04
LVEF <40% (HFrEF)	36 (33)	82 (46)	0.04
Severe LV dysfunction (LVEF<30%)	15 (14)	42 (24)	0.05
Heart failure specific Beta blockers (n, %)			
Nebivolol	42 (15)	81 (39)	<0.01
Bisoprolol, carvedilol, metoprolol succinate (CR)	100 (36)	68 (32)	0.39
Nebivolol, bisoprolol, carvedilol, metoprolol succinate (CR)	142 (52)	149 (71)	<0.01
RAAS blockers (n, %)			
ACEi	123 (45)	65 (31)	<0.01
ARB	63 (23)	41 (19)	0.43
MRA	75 (27)	72 (34)	0.11
Other (n, %)			
Amiodarone	11 (4)	8 (3)	1.00
Atenolol, metoprolol tartrate, sotalol	50 (18)	27 (13)	0.13
Ivabradine	2 (0)	6 (2)	0.08
Digoxin	64 (23)	59 (28)	0.25
GTN	44 (16)	47 (22)	0.08
Thiazides diuretics	27 (9)	29 (14)	0.20

Loop diuretics	255 (93)	193 (93)	0.85
Statin	142 (52)	92 (44)	0.10
Antithrombotic therapy			
Aspirin	164 (60)	110 (53)	0.14
Clopidogrel, prasugrel, ticagrelor	53 (19)	40 (19)	1.00
Dual antiplatelet therapy	30 (11)	27 (13)	0.57
Warfarin	66 (24)	52 (25)	0.83
Direct oral anticoagulant	6 (2)	36 (17)	<0.01
Anticoagulant and antiplatelet	24 (8)	34 (16)	0.02
Medications in HFrEF subgroup	n=36/272	n=82/207	
Bisoprolol, carvedilol, metoprolol succinate CR, nebivolol,	27 (75)	67 (82)	0.46
ACEi or ARB	28 (78)	51 (62)	0.14
MRA	14 (39)	34 (41)	0.84
Abbreviations: ACEi; Angiotensin converting enzyme inhibitor; ARB, Angiotensin receptor blocker; CCI, Charlson comorbidity index; COPD, chronic obstructive airways disease; HFpEF, Heart failure preserved ejection fraction; HFrEF, Heart failure reduced ejection fraction; IQR, Interquartile range; LVEF; Left ventricular ejection fraction; MRA, Mineralocorticoid receptor antagonist; NYHA, New York Heart Association; RAAS, Renin angiotensin aldosterone system; TTE, Transthoracic echocardiogram			

Table 2: Outcomes			
	Control (n=272)	Prospective (n=207)	P-value
30 day all cause readmission, no. %	59 (21.7)	53 (25.6)	0.33
365 day all cause readmission, no. %	185 (68)	141 (68.1)	1.00
30 day HF/death readmission, no. %	40 (14.7)	19 (9.2)	0.07
365 day HF/death readmission, no. %	123 (45.2)	78 (37.7)	0.11
30 day death, no. %	13 (4.8)	7 (3.4)	0.49
365 day death, no. %	65 (23.9)	56 (27)	0.46
365 day, median no. readmissions, min, max	1 (0,11)	1 (0,11)	0.50
365 day, median no. of nights in hospital, min, max	4 (0,144)	5 (0,132)	0.56
Length of hospital stay in days, median, IQR	4 (2-6)	4 (2-7)	0.04
Referred to subacute rehabilitation	19 (7)	35 (14)	<0.01
TTE Inpatient, no. %	49 (18)	98 (47)	<0.01
TTE +/- 6 months of admission, no. %	109 (40)	177 (86)	<0.01
Abbreviations: TTE; Transthoracic echocardiogram.			

Abstract Brief Communication

A 'Cardio-geriatric' heart failure model of care was implemented, to address the high rates of readmission in elderly acute decompensated heart failure patients. Despite demonstrably intensified management in both the cardiology and geriatric domains, this study did not demonstrate a positive effect on the primary outcome of all cause readmissions at 30 days.

Figure 1

Prospective group

Enrollment

Analysis

Control group

Enrollment

Analysis

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