

STUDY PROTOCOL

Open Access



The cardiac care bridge program: design of a randomized trial of nurse-coordinated transitional care in older hospitalized cardiac patients at high risk of readmission and mortality

L. Verweij^{1,2*†}, P. Jepma^{1,2†}, B. M. Buurman^{1,3}, C. H. M. Latour¹, R. H. H. Engelbert^{1,4}, G. ter Riet⁵, F. Karapinar-Çarkit⁶, S. Daliri^{2,6}, R. J. G. Peters² and W. J. M. Scholte op Reimer^{1,2}

Abstract

Background: After hospitalization for cardiac disease, older patients are at high risk of readmission and death. Although geriatric conditions increase this risk, treatment of older cardiac patients is limited to the management of cardiac diseases. The aim of this study is to investigate if unplanned hospital readmission and mortality can be reduced by the Cardiac Care Bridge transitional care program (CCB program) that integrates case management, disease management and home-based cardiac rehabilitation.

Methods: In a randomized trial on patient level, 500 eligible patients ≥ 70 years and at high risk of readmission and mortality will be enrolled in six hospitals in the Netherlands. Included patients will receive a Comprehensive Geriatric Assessment (CGA) at admission. Randomization with stratified blocks will be used with pre-stratification by study site and cognitive status based on the Mini-Mental State Examination (15–23 vs ≥ 24). Patients enrolled in the intervention group will receive a CGA-based integrated care plan, a face-to-face handover with the community care registered nurse (CCRN) before discharge and four home visits post-discharge. The CCRNs collaborate with physical therapists, who will perform home-based cardiac rehabilitation and with a pharmacist who advises the CCRNs in medication management. The control group will receive care as usual.

The primary outcome is the incidence of first all-cause unplanned readmission or mortality within 6 months post-randomization. Secondary outcomes at three, six and 12 months after randomization are physical functioning, functional capacity, depression, anxiety, medication adherence, health-related quality of life, healthcare utilization and care giver burden.

Discussion: This study will provide new knowledge on the effectiveness of the integration of geriatric and cardiac care.

Trial registration: NTR6316. Date of registration: April 6, 2017.

Keywords: Cardiology, Case management, Disease management, Transitional care, Rehabilitation

* Correspondence: l.verweij@hva.nl

[†]L. Verweij and P. Jepma contributed equally to this work.

¹ACHIEVE Center of Applied Research, Amsterdam University of Applied Sciences, Amsterdam, the Netherlands

²Department of Cardiology, Academic Medical Center, Amsterdam, the Netherlands

Full list of author information is available at the end of the article



Background

Cardiac disease is the leading cause of hospitalization and mortality [1]. In the population of older hospitalized cardiac patients, 20% are readmitted and 10% die within 1 month post-discharge [2]. In addition to cardiac disease, geriatric conditions such as impaired activities of daily living (ADL) (77%), cognitive impairment (42%) and fall risk (30%) are highly prevalent [3]. The assessment of geriatric conditions is not currently part of routine medical evaluation in cardiology. As a result, these conditions are often unrecognized [4, 5] leading to an increased risk of new disabilities, readmission and death [3, 6].

The transition of care in which patients transfer between different settings increases the risk for adverse health outcomes due to inadequate attention to patients' healthcare needs [7, 8]. For example, the failure to recognize geriatric conditions in older cardiac patients negatively impacts treatments post-discharge, e.g. because of nonadherence to (pharmacological) treatment in cognitively impaired patients [4] or poor participation in cardiac rehabilitation programs because of disabilities, the high intensity of these programs [9, 10], fatigue [11] and difficulties traveling to and from cardiac rehabilitation centers [12, 13]. This is unfortunate since cardiac rehabilitation has been shown to reduce cardiovascular risk factors, readmission and mortality in older cardiac patients [14].

Adequate guidance during hospitalization, during the transition from hospital to home and in the early post-discharge period may potentially reduce the risk of adverse events. Transitional care is a model that aims to continue care when patients transfer between different care settings, with a focus on patients' needs [15, 16]. Recently, the Transitional Care Bridge program resulted in a 25% (HR 0.75, 95% CI 0.56–0.99, $P = 0.045$) reduction in mortality in acutely hospitalized older patients, by combining a Comprehensive Geriatric Assessment (CGA), an integrated care plan and a transitional care program, including visits during hospitalization and soon after discharge by a community care registered nurse (CCRN) [17]. However, with this case management approach no effects were found on readmission rates and ADL-functioning. We hypothesize that this may be caused by a main focus on case management within the care transition program with a lack of attention for disease management and rehabilitation after discharge.

The RESPONSE study of Jorstad et al. [18] involved a nurse-coordinated outpatient intervention that included guidance on lifestyle factors, biometric risk factors and therapy adherence in patients after an acute coronary syndrome. In this disease management approach, a relative risk reduction of 17.4% ($P = 0.021$) was found on the Systematic Coronary Risk Evaluation (SCORE), which is an integrated measure to estimate the risk of

cardiovascular death in 10 years. In addition, a relative risk reduction of 34.8% ($P = 0.023$) was found on readmission.

Combining case management, disease management and home-based rehabilitation may have the potential to reduce readmission and mortality. Therefore, we developed the nurse-coordinated Cardiac Care Bridge transitional care program (CCB program) aiming to reduce unplanned hospital readmission and mortality in the first six months in comparison to usual care in older hospitalized cardiac patients at high risk of readmission and mortality. In this paper we report on the design of this program.

Methods/Design

This study follows the Standard Protocol Items for Interventional Trials (SPIRIT) checklist (Additional file 1) [19]. The next paragraphs describe the Cardiac Care Bridge program, the study design and research methods.

Design and setting

A single-blinded multi-center parallel group superiority trial with randomization at patient level will be performed in six hospitals in the Amsterdam region of the Netherlands: 1) Academic Medical Center (AMC), Amsterdam, 2) Amstelland Medical Center, Amstelveen, 3) BovenIJ Medical Center, Amsterdam, 4) Medical Center Slotervaart, Amsterdam, 5) Onze Lieve Vrouwe Gasthuis (OLVG), Amsterdam, 6) Tergooi Medical Center, Blaricum. In the transitional and post-clinical phase, five community nursing care organizations will participate: 1) Amstelring, 2) Buurtzorg Nederland, 3) Cordaan Home Care, 4) Evean, 5) Vivium Care Group. In the post-clinical phase, several community based physical therapists (PT) will participate. The recruitment for the study started on June 5, 2017 and will end after the last patient has been followed-up for 12 months, which is expected in December, 2019.

Study population

Potential participants are all cardiac patients 70 years and older, acutely or electively admitted to the departments of cardiology or cardiothoracic surgery and admitted ≥ 48 h. They are eligible for inclusion if they are at high risk of functional decline according to screening instrument for frail elderly of the Dutch Safety Management Program (VMS instrument, Table 1). Four geriatric conditions (ADL, falls, malnutrition and delirium) are part of this screening. Oud et al. [20] also found a positive association between an increase of the number of risk factors with the VMS instrument and risk of death. Heim et al. [21] studied the optimal predictive value of frailty on adverse outcomes (death, functional decline and high healthcare use) with the VMS instrument. The

Table 1 Screening tool for vulnerable elderly of the Dutch Safety Management Program

Risk domain	Instrument	Questions	Cut-off	Score ^a
Fall risk	Single question	Did you fall in the last 6 months?	yes = 1	1
Malnutrition	SNAQ [53]	Assessing whether the patient: 1) lost weight unintentionally in the last 36 months and/or 2) experiences a decreased appetite and 3) used supplemental drinks or tube feeding	Question 1 = yes or Question 2 + 3 = yes	1
Delirium	Single questions	Assessing whether: 1) the patient has cognitive impairment; 2) the patient needed help with self-care in the last 24 h; 3) the patient has previously undergone a delirium	≥ 1 point = 1	1
ADL-functioning	KATZ-6 [54]	Assessing whether the patient needs help with: 1) bathing, 2) dressing, 3) toileting, 4) transferring from bed to a chair, 5) eating, and 6) whether the patient uses incontinence material	≥ 2 points = 1	1
Total score				0–4

Abbreviations SNAQ Short nutritional assessment questionnaire, ADL Functioning activities of daily living-functioning, KATZ-6 Modified KATZ-6 index

^aPatients are at high risk of functional decline if aged 70–79 years and score ≥ 2 or aged ≥ 80 years and score ≥ 1

strongest predictive value was found by a positive score on ≥ 3 risk factors in patients aged 70–79 and a positive score on ≥ 1 risk factor in patients aged ≥ 80 years. However, the screening of malnutrition may not be sensitive in cardiac patients because of an increased risk of weight gain due to decompensated heart failure [22]. Therefore, we considered patients aged 70–79 years with ≥ 2 risk factors and patients aged ≥ 80 years with ≥ 1 risk factor eligible for inclusion. In addition, patients at high risk of readmission and mortality are eligible to participate if they have had an unplanned hospital admission in the previous 6 months. This risk factor is associated with an increased risk of further readmissions and mortality [23, 24].

Exclusion criteria are the following: 1) severe cognitive impairment, assessed with the Mini-Mental State Examination (MMSE < 15), 2) congenital heart disease, 3) terminal illness, defined as a life expectancy of less than 3 months as estimated by the treating physician, 4) transfer from or a planned discharge to a nursing home, 5) planned discharge to another department or another hospital not participating in this study, 6) inability to communicate in Dutch, 7) delirium as confirmed by patient's physician and not resolved within 4 days after hospital admission.

Randomization and blinding

After patients are screened for eligibility and have provided informed consent to a cardiac research nurse (CRN), the baseline assessment will be performed. After the baseline assessment patients will be randomized to the intervention or control group. Stratified block randomization (1:1) will be used with pre-stratification by study site and cognitive status based on the MMSE (15–23 vs ≥ 24). To ensure allocation concealment, a web-based data management program (Research Manager, <http://deresearchmanager.nl/home/>) [25] and random permuted blocks of variable sizes will be used.

Group assignment will be blinded to patients. They will be informed that the study aim is to study different

forms of post-discharge care and will receive only general information about the study protocol according to the postponed informed consent procedure of Boter et al. [26] Patients will be blinded to the aim of the intervention to prevent a potential Hawthorne effect [27, 28]. At the end of follow-up, patients (or their caregivers) will be fully informed about the content of the study intervention and the allocated treatment they received. Healthcare practitioners who execute the intervention cannot be blinded. Outcome assessments will be performed by research nurses who are blinded to the allocated treatment. Statistical analyses will be performed according to a predefined statistical analysis plan (see Statistical Analysis paragraph) by investigators blinded to group assignment.

Due to the minimal expected side effects related to the intervention of the CCB care program a data monitoring committee is not mandatory for this trial.

Hospital care for all included patients

Table 2 shows the time frame and components of the CCB program in the intervention and control groups. All included patients will receive a CGA within 72 h after admission by a CRN, which will also serve as the baseline study measurement (Table 3). The CGA identifies health issues in the somatic, psychological, social and functional domains, including problems related to polypharmacy, malnutrition, fall risk, delirium, depression and quality of life. Cardiovascular risk factors (e.g. body mass index, smoking, alcohol use and physical performance) will also be assessed. Following assessment, consenting patients will be randomized to the intervention or control group.

Intervention

The CCB program encompasses three phases of the care process: 1) clinical phase, 2) discharge phase from hospital to home and 3) post-clinical phase after hospital discharge. The intervention consists of three components: 1)

Table 2 Time frame and components of the Cardiac Care Bridge program and the control group

Time Frame	Intervention component	Baseline – outcome measures	Professionals involved	Intervention	Control
Clinical phase					
≤ 72 h after hospital admission	CGA ^a	Baseline	CRN ^b	X	X
≤ 72 h after hospital admission	Integrated care plan		CRN ^b	X	
During hospital stay	Geriatric team consultation in case of ≥ 5 identified health issues or ≥ 1 psychological issue		CRN ^b , CNS ^c , geriatrician	X	
Discharge phase					
Before hospital discharge	In-person handover of the CGA ^a , integrated care plan and medical treatment plan		CRN ^b , CCRN ^d	X	
Before hospital discharge	Visit of CCRN ^d to participant		CCRN ^d	X	
At discharge	Medical discharge letter		Cardiologist, GP ^e , CCRN ^d	X	X
Post-clinical phase					
≤ 2 days after hospital discharge	Home visit 1. Medication reconciliation and integrated care plan		CCRN ^d	X	
≤ 1 week	Home visit 2. Intake home based cardiac rehabilitation and integrated care plan		CCRN ^d , PT ^f	X	
Week 1	Two home-based cardiac rehabilitation sessions		PT ^f	X	
Week 2	Two home-based cardiac rehabilitation sessions		PT ^f	X	
Week 3	Home visit 3. lifestyle promotion and self-management		CCRN ^d PT ^f	X X	
	Two home-based cardiac rehabilitation sessions		PT ^f	X	
Week 4	Two home-based cardiac rehabilitation sessions		PT ^f	X	
Week 5	Two home-based cardiac rehabilitation sessions				
Week 6	Home visit 4. Evaluation of integrated care plan and home-based cardiac rehabilitation		CCRN ^d PT ^f	X X	
	Two home-based cardiac rehabilitation sessions				
≤ 12 weeks	Home visit 5. If indicated by the CCRN ^d				
3 months		Follow-up telephone	Research Nurse	X	X
6 months		Follow-up home visit	Research Nurse	X	X
12 months		Follow-up telephone	Research Nurse	X	X

^aComprehensive Geriatric Assessment (CGA)^bCardiac Research Nurse (CRN)^cClinical Nurse Specialist in geriatrics (CNS)^dCommunity Care Registered Nurse (CCRN)^eGeneral Practitioner (GP)^fPhysical therapist (PT)

case management, 2) disease management and 3) home-based cardiac rehabilitation. Medication management is an important topic in the three phases of the CCB intervention and is part of all three components.

Phase 1: Clinical phase

Patients randomized to the intervention group will receive an integrated care plan based on geriatric and cardiac conditions identified by the CGA. This plan will be

Table 3 Baseline assessment, outcome measures and time points in the Cardiac Care Bridge

	CGA	Question or instrument	T0*	T0+ [†]	T1 [‡]	T2 [§]	T3
Sociodemographic data							
Age		Date of birth	X [¶]				
Gender			X [¶]				
Postal code			X				
Living arrangement			X				
Marital status			X				
Ethnicity		Patients' country of birth	X				
Education			X				
Mortality		Date of death	X [¶]		X [¶]	X [¶]	X [¶]
Medical data							
Diagnosis (and history) of cardiac disease			X [¶]				
Comorbidities		CCI [55]	X [¶]				
Date of hospitalization			X [¶]				
Hospitalization department			X				
Functional domain							
ADL- and iADL-functioning	+	ALDS [35]	X		X	X	X
Functional status		Specific Activity Scale [33]	X			X	
Hearing impairment	+	Do you experience difficulties with hearing, despite the use of a hearing aid?	X				
Visual impairment	+	Do you experience difficulties with your vision, despite the use of glasses?	X				
Fatigue	+	NRS	X			X	
Falls	+	Frequency	X		X	X	X
Fear of falling	+	NRS	X		X	X	X
Physical domain							
Nutritional status	+	SNAQ [53]	X		X	X	X
Pain	+	NRS [56]	X			X	
Dizziness	+	Do you currently suffer from dizziness. If yes, does this affect your daily living?	X			X	
Shortness of breath	+	Do you currently suffer from shortness of breath? If yes, does this affect your daily living?	X			X	
Angina pectoris	+	Do you currently suffer from angina pectoris. If yes, does this affect your daily living?	X			X	
Heart palpitations	+	Do you currently suffer from heart palpitations? If yes, does this affect your daily living?	X			X	
Incontinence	+	Do you suffer from incontinence? If yes, do you suffer from incontinence of urine and/or defecation?	X			X	
Presence of urinary catheter	+	Do you have a urinary catheter? If yes, did you have the urinary catheter before hospitalization?	X			X	
Nycturia	+	Do you currently suffer from nycturia? If yes, does this affect your daily living?	X			X	
Handgrip strength	+	Jamar [57]	X			X	
Psychological domain							
Cognitive status	+	MMSE [58]	X			X	
Depression & apathy	+	GDS-15[41]	X			X	
Anxiety	+	HADS-A [38]	X		X	X	X
Quality of life	+	EQ-5D-5 L [40]	X		X	X	X

Table 3 Baseline assessment, outcome measures and time points in the Cardiac Care Bridge (Continued)

	CGA	Question or instrument	T0*	T0 + [†]	T1 [‡]	T2 [§]	T3
Smoking status		Do you smoke or did you smoke in the past? If yes, how many cigarettes per day and for how many years?	X		X	X	X
Alcohol use		AUDIT-C [59]	X		X	X	X
Social domain							
Caregiver burden		TOPIC-MDS [41]	X			X	X
Medication use							
Polypharmacy	+	Do you use five or more different medications?	X			X	
Medication adherence	+	Medication Adherence Questionnaire	X		X	X	X
Side effect of medication	+	Do you experience difficulties or side effects with medication use?	X			X	
Type of medication		Type, frequency and dose of medication	X [¶]		X [¶]	X [¶]	X [¶]
Physical performance							
Physical performance		30-s chair stand test [60]		X		X	
Mobility		SPPB [36]	X			X	
Physical capacity		2 MST [37]	X	X		X	
Perceived exertion		Borg RPE scale [61]	X	X		X	
Dyspnoea		MRC dyspnoea scale [62]		X		X	
Parameters							
BMI		Weight and length	X			X	
Waist circumference			X			X	
Blood pressure		mmHg	X			X	
Heart frequency		BPM	X			X	
Respiratory rate			X			X	
Blood parameters		Hemoglobin	X [¶]		X [¶]	X [¶]	X [¶]
		Albumin	X [¶]		X [¶]	X [¶]	X [¶]
		Creatinine	X [¶]		X [¶]	X [¶]	X [¶]
		Total cholesterol	X [¶]		X [¶]	X [¶]	X [¶]
		LDL-cholesterol	X [¶]		X [¶]	X [¶]	X [¶]
		HDL-cholesterol	X [¶]		X [¶]	X [¶]	X [¶]
		Triglyceride	X [¶]		X [¶]	X [¶]	X [¶]
		Glucose / HbA1C	X [¶]		X [¶]	X [¶]	X [¶]
Healthcare utilization		TOPIC-MDS [41]					
Readmission		Have you been hospitalized in the last six months? If yes, what was the hospitalization diagnosis and in what hospital were you readmitted?			X [¶]	X [¶]	X [¶]
Emergency visits		Have you visited the emergency or cardiac emergency room in the last six months? If yes, how many times and for what reason?			X*	X*	X*
Nursing home admission		Have you been admitted to a nursing home in the last months? If yes, for how many weeks?			X	X	X
General practice consult		Have you had a consult with your general practitioner in the last month? If yes, was this during office hours or during the evening, night or weekend and how many times in total?			X	X	X
Home visit of GP		Have you had a home visit from your GP in last month? If yes, was this during office hours or during the evening, night or weekend, and how many times in total?			X	X	X
Home care					X	X	X

Table 3 Baseline assessment, outcome measures and time points in the Cardiac Care Bridge (Continued)

CGA	Question or instrument	T0*	T0+ [†]	T1 [‡]	T2 [§]	T3
	Do you receive home care? If yes, is this care assistance and/or domestic help, and how many hours per week?					
Day care	Do you have day care? If yes, how many days per week?			X	X	X
Cardiac rehabilitation use	Do you participate in cardiac rehabilitation in a rehabilitation center or outpatient clinic?			X	X	X
Physical therapy	Do you participate in cardiac rehabilitation in a rehabilitation center or outpatient clinic?			X	X	X

Abbreviations CCI Charlson comorbidity index, ALDS Amsterdam linear disability scale, NRS numeric rating scale, SNAQ short nutritional assessment questionnaire, MMSE mini mental state examination, GDS-15 geriatric depression Scale-15, HADS-A hospital anxiety and depression scale-anxiety subscale, EuroQol-5D Euroqol quality of life, MDS minimal dataset, SPPB short physical performance battery, 2MST 2 Minute step test, Borg RPE scale ratings of perceived exertion scale, MRC Dyspnea Scale Medical Research Council dyspnea scale, mmHg millimetre of mercury, BPM beats per minute

*T0: baseline, ≤ 48 h after admission; [†]T0+: within 2 weeks after hospitalization during home-based cardiac rehabilitation intake; [‡]T1: 3 months after hospitalization, follow-up by telephone; [§]T2: 6 months after hospitalization, follow-up by home visit; ^{||}T3: 12 months after hospitalization, follow-up by telephone.

[¶]Data will be obtained from the medical record

developed by the CRN together with the patient as follows. The CRN discusses identified health issues, asks if the patient recognizes them and what issues they prioritize for treatment. The integrated care plan is used to prioritize care during the three phases of the intervention. In case of ≥ 1 health issue in the psychological domain or ≥ 5 potential health issues in total, the geriatrician will be consulted. If indicated, the CRN also consults with other disciplines.

Phase 2: Discharge phase

At least one day before discharge, the CCRN visits the patients to discuss and prepare discharge to home. A personalized face-to-face handover between the CRN and the CCRN is completed using a standardized discharge checklist. In case of logistical difficulties the handover is performed by video call via tablet. The CGA, integrated care plan and ongoing interventions are discussed. In addition, the current medical condition, medication prescriptions and therapy advises a patient needs to adhere to (e.g. fluid restrictions in case of heart failure) are discussed. Finally, the CRN contacts the primary care PT by telephone to arrange home-based cardiac rehabilitation.

Phase 3: Post-clinical phase

After discharge home, the CCRN and PT continue care at home. The focus of these visits is in the first month post-discharge since this is when patients are at highest risk for readmission, mortality and functional decline [2, 3]. The CCRN visits the patient four times post-discharge; within 2 days, at 1, 3 and 6 weeks and if needed one more visit within 12 weeks post-discharge. During all home visits, the CGA, the integrated care plan and patients' current medical condition is evaluated. During the first home visit medication reconciliation is performed by the CCRN to obtain the most accurate possible list of a

patient's current medications [29, 30]. This is done by comparing all the medications that the patient is taking (including over-the-counter drugs, herbals and vitamins) to those listed in the provided medication records (medication overview from the community pharmacy and the discharge summary from the hospital). Within 48 h after discharge the discharge summary, which contains an overview of the medications at discharge, reasons for changes in medication and results of diagnostic tests is sent from the hospital to the CCRN and pharmacist who is part of the research team.

In Table 2, the home visit schedule is presented, including specific themes during the home visits. The CCRN is allowed to deviate from the home visit schedule if indicated, for example because of changes in patients' health status. During the home visits, the CCRN will indicate and refer if there is a need for additional care (domiciliary or otherwise) during or after the intervention period. For specific questions related to patients' health status or medication discrepancies identified during medication reconciliation, the CCRN has access to the cardiac team of the hospital, the general practitioner (GP), pharmacist according to local communication routes or protocols of the hospitals. During the home visits the CCRN observes signs and symptoms of actual or potential drug-related problems (DRP), such as side-effects and inappropriate medication use (e.g. nonadherence) by using a recently developed instrument (Additional file 2. Adapted Red Flag instrument) based on the Red Flag instrument by Sino et al. [31] The observed problems are documented by the CCRN in the Adapted Red Flag instrument and evaluated by the pharmacist-investigator who has identified DRP and proposed suitable solutions. Subsequently the CCRN discusses these DRP and proposed solutions with the responsible healthcare providers.

The PT provides two home-based cardiac rehabilitation sessions per week during the first 6 weeks post-discharge. This program is based on therapy advice according to the Dutch multidisciplinary guideline of cardiac rehabilitation [32]. Depending on the patient's functional status a stepwise graded exercise approach will be followed, starting with low intensity functional rehabilitation (class IV or higher on the Specific Activity Scale [33]) to the Metabolic Equivalent of Task level [34] (MET-level) needed for their goals and desired activities, as described in the rehabilitation plan. Exercise therapy will be adapted to comorbid diseases according to current guidelines. Within the last 2 weeks of the rehabilitation program, patient's functional status will be evaluated. The CCRN and PT work in close collaboration during the intervention to tailor care and to evaluate progress. They have a joint home visit in the first week after discharge to verify and agree on the integrated care plan in relation to patients' priorities.

In case of readmissions to participating hospitals and wards during the study follow-up of 12 months, patients will repeatedly receive the CCB program with exception of the rehabilitation exercise component. This is due to the limit on physical therapy sessions funded by Dutch healthcare insurance policies.

Usual care

Patients in the control group will receive usual care during hospitalization and after discharge. During hospitalization, other disciplines are consulted as needed. The control group may receive geriatric care if the patients' treating physician consults the geriatric team. All participating hospitals have a geriatric consultation team that can be consulted by the patients' treating physician on indication. After discharge, care as usual may include medical care by a cardiologist according to the national cardiovascular guidelines and a cardiac nurse specialist, if available. Also, control group patients can be referred to center-based cardiac rehabilitation. According to the Dutch multidisciplinary guideline of cardiac rehabilitation, center-based cardiac rehabilitation consists two one-hour exercise sessions per week during 6 weeks [32]. However, it is expected that only a small number of patients in the control group will receive center-based cardiac rehabilitation due to their age, illness and clinical complexity.

Standard primary care will be provided in both the intervention and the control group. For non-cardiovascular problems, the GP is the primary healthcare provider. Optional care provision in the GP practice includes secondary prevention, medication titration, regular evaluations of physical health status and referral to other disciplines. In both groups the GP will be informed about the hospitalization by a discharge letter from the medical

specialist. In the intervention group the GP is informed about the patients' study participation by letter. During the intervention, the CCRN will be an extra liaison between care providers in case of medical, mental or social issues.

In the Netherlands virtually all citizens have basic healthcare insurance, which includes coverage of primary care visits, hospital outpatient visits, hospitalizations and prescribed medication. Dutch citizens can also purchase optional supplementary insurance, which includes physical therapy and other services.

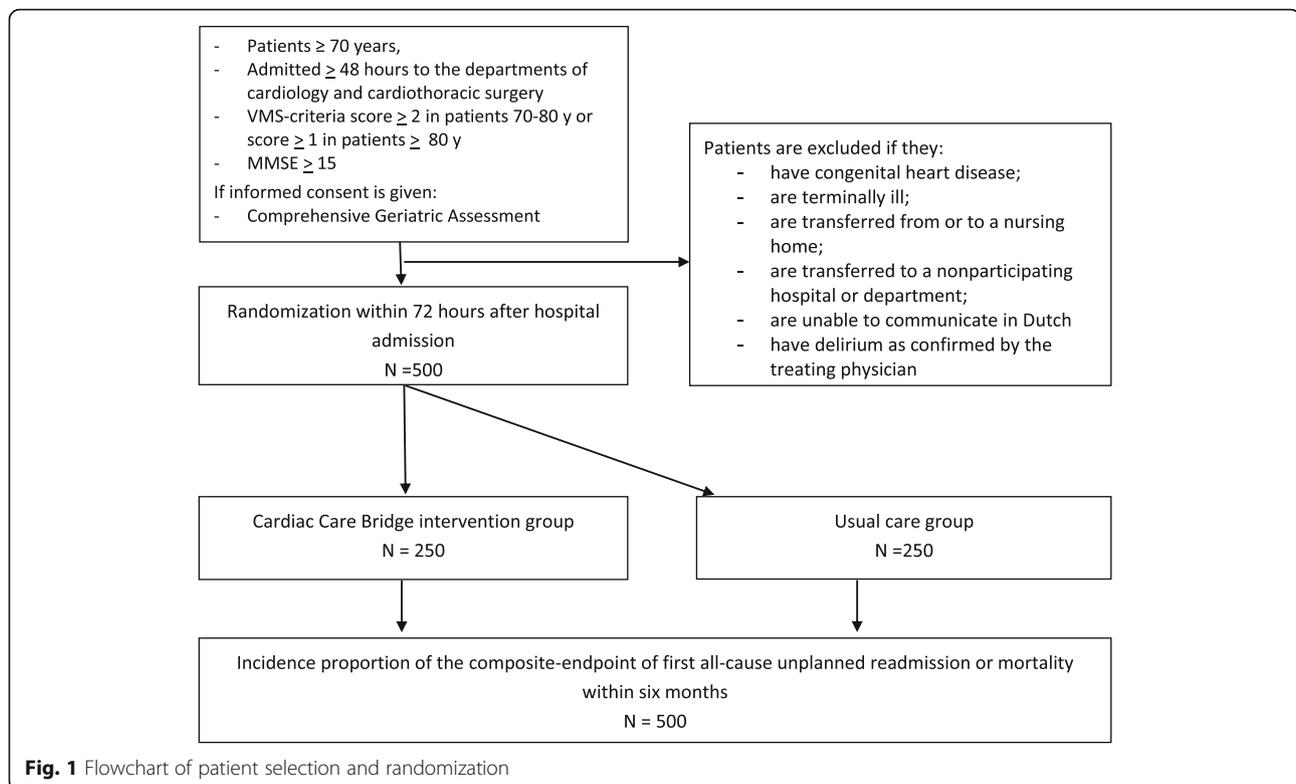
Training for healthcare providers and implementation

The CCB program combines case management, disease management and home-based cardiac rehabilitation, which require additional skills of healthcare providers. The participating CRNs and CCRNs will therefore follow a 5-day training program focussing on case management and disease management which addresses geriatric conditions, the performance of the CGA, development of an integrated care plan, pathophysiology of common cardiac diseases, early detection of physical deterioration and complications, pharmaceutical treatments and cardiac rehabilitation, including lifestyle counselling [9–13]. The participating PTs followed 2,5 day of the 5-day training program together with the CRNs and CCRNs, focussing on pathophysiology of common cardiac diseases, early detection of physical deterioration and complications, pharmaceutical treatments and cardiac rehabilitation, including lifestyle counselling.

We performed a feasibility process in six participating hospitals from June 2016 until May 2017 to check for potential inclusion rates to implement the study protocol and to train CRNs in data collection. In total 45 patients were included in this pilot phase. After successful implementation, we started the official inclusion stepwise per hospital with the first hospitals starting in June 2017.

Sample size calculation

The sample size calculation is based on findings in a relevant subpopulation (101/674) of cardiac patients of the Transitional Care Bridge program [17], a comparable study including hospitalized patients ≥ 65 years at high risk of functional decline. Based on a six-month incidence rate of 44% (readmission and mortality combined) in the usual care subpopulation of the Transitional Care Bridge program and a minimal important difference of 12.5% in absolute risk reduction (from 44 to 31.5%) in patients in the intervention arm, (2-sided alpha of 0.05; power of 80%), a sample size of 235 patients per group is required. To compensate for an assumed 5% loss to



follow-up, the total sample size per group will be 250 (Fig. 1).

Outcomes and measurements

Primary outcome

The primary outcome is the incidence of first all-cause unplanned readmission or mortality within 6 months post-randomization.

Secondary outcomes

Secondary outcomes will be measured at three, 6 and 12 months. Data will be collected by telephone at three and 12 months and at 6 months by a home visit of a blinded research nurse. Table 3 provides an overview of the data collection on different time points. The secondary outcomes are the following:

- The incidence of the first all-cause unplanned hospital readmission or mortality within 3 months and 12 months after randomization (triangulated by self-reporting and hospital data management system)
- Activities of Daily Living (ADL)- / instrumental ADL-functioning at 3, 6 and 12 months after randomization (the AMC Linear Disability Score) [35]
- Functional capacity at 6 months after randomization (Short Physical Performance Battery [36] and 2-min step test [37])

- Medication adherence (questionnaire and pharmacy dispensing records) at 3, 6 and 12 months after randomization
- Anxiety and depression at 6 months after randomization (HADS-anxiety [38] and Geriatric Depression Scale-15 [39])
- Health-related quality of life at 6 and 12 month after randomization (EuroQol-5D-5 L) [40]
- Healthcare utilization at 3, 6 and 12 months after randomization (extension of *The Older Persons and Informal Caregivers Survey - Minimum Data Set (TOPIC-MDS)* [41] including readmission, emergency visits, GP visits, physical therapy and cardiac rehabilitation)
- Caregiver burden, at 6 and 12 months after randomization (TOPIC-MDS) [41]

Statistical analyses

All analyses will be performed according to a predefined statistical analysis plan, which is published in the Netherlands Trial Register (NTR6316). The primary analyses will be performed according to the intention-to-treat principle. Outcomes will be reported as unadjusted risk differences and their 95% confidence intervals. Adjusted analyses using multivariable logistic or linear regression models, as appropriate, will focus on the incidence proportion of the

composite endpoint of readmission and mortality up to 6 months. All analyses will be adjusted for the following potential confounders: age, sex, Charlson Comorbidity Score, MMSE, cardiovascular diagnosis, length of stay and living arrangement. In addition, subgroup analyses will be performed for cardiac diagnosis, frailty status with the VMS screening tool, cognitive status with the MMSE and social economic status. Data will be collected by an electronic Case Record Form in Research Manager [25], a web-based data management program. Multiple imputation will be used as a sensitivity analysis to assess the impact of missing values.

Cost effectiveness analysis

We will perform a cost-effectiveness analysis from a societal perspective. Incremental cost-effectiveness ratios (ICERs) will be calculated by dividing the difference in total costs between the intervention group and the control care group by difference in readmission/mortality rates and Quality Adjusted Life Years (QALYs). The uncertainty surrounding the ICERs will be estimated with non-parametric bootstrapping (5000 replications). The intention to treat principle will be applied to analyse the data. Missing values for cost and effect data will be predicted by multiple imputation.

Process evaluation

Quantitative data will be collected by using pre-defined process indicators to measure study performance and adherence to the intervention by the patient, CRN, CCRN and PT. Process indicators will be used to study fidelity and adherence to the study protocol. Process indicators are focussed on documentation, communication between healthcare providers, consultation of disciplines, referral to healthcare providers and medication issues. All process indicators will be quantified by nominator and denominator and collected through existing resources. Usual care will be documented to be able to assess the difference between the intervention and control group. In addition, qualitative data will be collected during the intervention by focus groups with healthcare providers and in semi-structured interviews with patients and informal caregivers to evaluate satisfaction with the intervention. These data will be analysed to identify factors that promote or impede future implementation of the CCB care program.

(Serious) adverse events

Study related adverse events (AE) will be reported when the AE occurs during the comprehensive geriatric assessment and baseline data collection or after discharge when the AE occurs during the home visits by the CCRN or

during the physical therapy sessions / self-practice physical therapy sessions by the patients within the intervention period (till 12 weeks post-discharge). After 12 weeks, the intervention has stopped. Therefore, serious adverse events after this period are not expected to be caused by the study and will only be recorded during the annual security reports.

Discussion

This protocol for a multi-center randomized controlled trial is designed to prevent hospital readmission and mortality after hospitalization in cardiac patients ≥ 70 years old who have been admitted to the department of cardiology or cardiothoracic surgery. Older patients who are discharged after hospitalization for a cardiac disease are at high risk of adverse outcomes, in particular early readmission and mortality [42, 43]. This vulnerable patient population is currently underrepresented in medical research, resulting in a lack of evidence on how to improve their outcomes [44–46].

In this paper we describe the study protocol of the CCB care program in which we combine three care components: case management, disease management and home-based cardiac rehabilitation that will be provided during and after hospitalization for cardiac disease. Multidisciplinary collaboration between the in-hospital cardiac team, including the CRN and the cardiologist, the clinical nurse specialist in geriatrics and the pharmacist, CCRN and PT in primary care, is an important part of the study intervention. By introducing face-to-face ('warm') handovers before discharge and a joint home visit of the CCRN and PT and support from a pharmacist, we expect to reduce information loss, improve the continuity of treatment, leading to a decrease in readmission and mortality.

Current literature on transitional care and cardiac rehabilitation in older high risk patients focuses mainly on the separate components of case management, disease management and home-based cardiac rehabilitation. In the recent Transitional Care Bridge program, a nurse-coordinated transitional intervention in acutely hospitalized high-risk older patients led to a 25% reduction in mortality, HR 0.75; 95% CI 0.56–0.99. However, there was less impact on time to first hospitalization, HR 1.21; 95% CI 0.91–1.60 [17]. The RESPONSE trial, a nurse-coordinated disease management intervention after a coronary syndrome led to a 35% reduction in readmission rates and 17.5% reduction in cardiovascular risk factors in a general cardiac patient population aged < 80 years [18]. Studies on cardiac rehabilitation in the elderly found positive trends on patients' functional ability [9, 47]. However, most of these were pilot studies with limited power. In addition to the heterogeneity of the study effects of these studies, the components do

not fully meet patients' needs in the care continuum [48]. Therefore, we expect that a combination of care components focusing on patients' needs has a greater likelihood of being effective. The Korinna trial [49] combined both case management and disease management in older patients after a myocardial infarction, but did not find a relevant effect on hospital readmission (HR 1.01; 95% CI 0.72–1.41). Compared to the intervention in the Korinna trial [49], the CCB program is focussed on a broader cardiac patient population instead of patients after acute myocardial infarction only. Other differences are the emphasis of the CCB program on the first period after hospitalization with a first home visit within 2 days after discharge and the additional home based cardiac rehabilitation program.

Strengths and limitations

The first strength of this study is that it includes a wider variety of the cardiac patient population than previous studies. This is because it selects patients based on their risk of readmission and mortality, instead of diagnosis, and because it selects from six hospitals in both an urban and a rural area. Second, this study has a robust design and includes a postponed informed consent procedure, which assures high internal validity. Third, a comprehensive geriatric assessment is used to develop a personalized care plan, including cardiac and geriatric care, that is transferrable across settings and healthcare providers. Fourth, due to the comprehensive nature of the intervention, it will not be possible to evaluate separate intervention components on their effectiveness but by use of process indicators we will collect data on the execution of the components of the intervention and performance of the involved healthcare providers to support interpretation of the study results. Finally, the intervention has been designed in multi-disciplinary collaboration between nurses, physical therapists, pharmacists and physicians.

This study also has some limitations. First, we exclude patients with delirium and dementia. These patients are at risk for readmission [50] and mortality [51, 52] and therefore could potentially benefit from this intervention. However, it is not possible to include these patients in the CCB program because of ethical considerations. Secondly, the face-to-face handover between the CRN and CCRN is a promising intervention but also challenging due to logistical difficulties as, for example, the sometimes unpredictable discharges from the hospital. An alternative handover was introduced by video call via tablets.

In summary, the CCB program aims to significantly reduce the primary composite endpoint of unplanned hospital readmission and mortality in older cardiac patients.

Additional files

Additional file 1: Standard Protocol Items Recommendations for Interventional Trials (SPIRIT) Checklist of the Cardiac Care Bridge program study protocol. (DOC 121 kb)

Additional file 2: Adapted Red Flag Instrument. Adapted version of the Red Flag Instrument by Sino et al. [33]. (DOCX 39 kb)

Abbreviations

2MST: 2 Minute Step Test; *ADL-functioning*: Activities of Daily Living-functioning; *ALDS*: Amsterdam Linear Disability Scale; *Borg RPE scale*: Ratings of Perceived Exertion scale; *BPM*: Beats per minute; *CCI*: Charlson Comorbidity Index; *CCRN*: Community Care Registered Nurse; *CGA*: Comprehensive Geriatric Assessment; *CNS*: Clinical Nurse Specialist in geriatrics; *CRN*: Cardiac Research Nurse; *EuroQoL-5D*: Euroqol quality of life; *GDS-15*: Geriatric Depression Scale-15; *GP*: General Practitioner; *HADS-A*: Hospital Anxiety and Depression Scale-Anxiety subscale; *KATZ-6*: Modified KATZ-6 index; *MDS*: Minimal Dataset; *MmHg*: Millimetre of mercury; *MMSE*: Mini Mental State Examination; *MRC Dyspnea Scale*: Medical Research Council Dyspnea Scale; *NRS*: Numeric Rating Scale; *PT*: Physical therapist; *SBSQ-D*: Set of Brief Screening Questions – Dutch; *SNAQ*: Short Nutritional Assessment Questionnaire; *SPPB*: Short Physical Performance Battery

Funding

This study is funded by a grant from the Netherlands Organization for Health Research and Development (ZonMw) as part of the 'From knowledge to Action II program', grant number 520002002 and is partly financed by the Netherlands Organisation for Scientific Research (NWO) grant numbers 023.008.024 (LV) and 023.009.036 (PJ). The funders had no role in study design, data collection and analysis neither in the preparation or publication of the manuscript.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request after the study database has been closed. Trial results will be offered for publication in a peer reviewed journal.

Authors' contributions

LV and PJ drafted the manuscript and wrote the protocol for the Medical Ethics Committee. BB, GtR, RP and WSR critically reviewed the manuscript and protocol for the Medical Ethics Committee. BM and WSR drafted the research proposal. CL, RE and RP reviewed the research proposal that was sent to the funding organization. GtR was involved in the methodological construct of the study. LV, PJ, BB, CL, RE, GtR, FK, SD, RP and WSR were all involved in the development and approved the final version of the manuscript.

Ethics approval and consent to participate

The CCB program has been approved by the Medical Ethics Committee of the AMC in the Netherlands (Protocol ID: MEC2016_024). Any relevant adjustments to the study protocol will be communicated to the Medical Ethics Committee of the AMC and to the Netherlands Trial Register. The study will be conducted in accordance with the Dutch Medical Research Involving Human Subjects and the WMA Declaration of Helsinki (1964). All patients will provide written informed consent before the start of the study. Netherlands Trial Register number: NTR6316, version 1 April 6th 2017.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹ACHIEVE Center of Applied Research, Amsterdam University of Applied Sciences, Amsterdam, the Netherlands. ²Department of Cardiology, Academic Medical Center, Amsterdam, the Netherlands. ³Department of Internal Medicine, Section of Geriatric Medicine, Academic Medical Center, Amsterdam, the Netherlands. ⁴Department of Rehabilitation, Academic Medical Center, Amsterdam, the Netherlands. ⁵Department of General Practice, Academic Medical Center, Amsterdam, the Netherlands. ⁶Department of Clinical Pharmacy, OLVG hospital, Amsterdam, the Netherlands.

Received: 5 March 2018 Accepted: 15 June 2018

Published online: 28 June 2018

References

- Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart disease and stroke Statistics-2017 update: a report from the American Heart Association. *Circulation*. 2017;135(10):e146–603.
- Krumholz HM, Lin Z, Keenan PS, Chen J, Ross JS, Drye EE, et al. Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. *JAMA*. 2013;309(6):587–93.
- Buurman BM, Hoogerduijn JG, van Gemert EA, de Haan RJ, Schuurmans MJ, de Rooij SE. Clinical characteristics and outcomes of hospitalized older patients with distinct risk profiles for functional decline: a prospective cohort study. *PLoS One*. 2012;7(1):e29621.
- Dodson JA, Chaudhry SI. Geriatric conditions in heart failure. *Curr Cardiovasc Risk Rep*. 2012;6(5):404–10.
- Bell SP, Orr NM, Dodson JA, Rich MW, Wenger NK, Blum K, et al. What to expect from the evolving field of geriatric cardiology. *J Am Coll Cardiol*. 2015;66(11):1286–99.
- Sanchez E, Vidan MT, Serra JA, Fernandez-Aviles F, Bueno H. Prevalence of geriatric syndromes and impact on clinical and functional outcomes in older patients with acute cardiac diseases. *Heart*. 2011;97(19):1602–6.
- Naylor MD, Shaid EC, Carpenter D, Gass B, Levine C, Li J, et al. Components of comprehensive and effective transitional care. *J Am Geriatr Soc*. 2017;65(6):1119–25.
- Naylor MD, Aiken LH, Kurtzman ET, Olds DM, Hirschman KB. The care span: the importance of transitional care in achieving health reform. *Health Aff*. 2011;30(4):746–54.
- Dolansky MA, Moore SM. Older adults' use of postacute and cardiac rehabilitation services after hospitalization for a cardiac event. *Rehabil Nurs*. 2008;33(2):73–81.
- van Jaarsveld CH, Sanderman R, Miedema I, Ranchor AV, Kempen GI. Changes in health-related quality of life in older patients with acute myocardial infarction or congestive heart failure: a prospective study. *J Am Geriatr Soc*. 2001;49(8):1052–8.
- Grando VT, Buckwalter KC, Maas ML, Brown M, Rantz MJ, Conn VS. A trial of a comprehensive nursing rehabilitation program for nursing home residents post-hospitalization. *Res Gerontol Nurs*. 2009;2(1):12–9.
- Jackson L, Leclerc J, Erskine Y, Linden W. Getting the most out of cardiac rehabilitation: a review of referral and adherence predictors. *Heart*. 2005;91(1):10–4.
- Yohannes AM, Yalfani A, Doherty P, Bundy C. Predictors of drop-out from an outpatient cardiac rehabilitation programme. *Clin Rehabil*. 2007;21(3):222–9.
- Doll JA, Hellkamp A, Thomas L, Ho PM, Kontos MC, Whooley MA, et al. Effectiveness of cardiac rehabilitation among older patients after acute myocardial infarction. *Am Heart J*. 2015;170(5):855–64.
- Verhaegh KJ, MacNeil-Vroomen JL, Eslami S, Geerlings SE, de Rooij SE, Buurman BM. Transitional care interventions prevent hospital readmissions for adults with chronic illnesses. *Health Aff*. 2014;33(9):1531–9.
- Feltner C, Jones CD, Cene CW, Zheng ZJ, Sueta CA, Coker-Schwimmer EJ, et al. Transitional care interventions to prevent readmissions for persons with heart failure: a systematic review and meta-analysis. *Ann Intern Med*. 2014;160(11):774–84.
- Buurman B, Parlevliet J, Allore H, Blok W, van Deelen B, Moll van Charante E, et al. Comprehensive geriatric assessment and transitional Care in Acutely Hospitalized Patients - the transitional care bridge randomized clinical trial. *JAMA Intern Med*. 2016;176(3):302–9.
- Jorstad HT, von Birgelen C, Alings AM, Liem A, van Dantzig JM, Jaarsma W, et al. Effect of a nurse-coordinated prevention programme on cardiovascular risk after an acute coronary syndrome: main results of the RESPONSE randomised trial. *Heart*. 2013;99(19):1421–30.
- Chan AW, Tetzlaff JM, Altman DG, Laupacis A, Gotzsche PC, Krleza-Jeric K, et al. SPIRIT 2013 statement: defining standard protocol items for clinical trials. *Ann Intern Med*. 2013;158(3):200–7.
- Oud FM, de Rooij SE, Schuurman T, Duijvelaar KM, van Munster BC. Predictive value of the VMS theme 'Frail elderly': delirium, falling and mortality in elderly hospital patients. *Ned Tijdschr Geneesk*. 2015;159:A8491.
- Heim N, van Fenema EM, Weverling-Rijnsburger AW, Tuijl JP, Jue P, Oleksik AM, et al. Optimal screening for increased risk for adverse outcomes in hospitalised older adults. *Age Ageing*. 2015;44(2):239–44.
- Chaudhry SI, Wang Y, Concato J, Gill TM, Krumholz HM. Patterns of weight change preceding hospitalization for heart failure. *Circulation*. 2007;116(14):1549–54.
- Pinho-Gomes AC, Silva Cardoso J, Azevedo LF, Almeida R, Pinho T, Maciel MJ. Characterization of acute heart failure hospitalizations in a Portuguese cardiology department. *Rev Port Cardiol*. 2013;32(7–8):567–75.
- Mudge AM, Kasper K, Clair A, Redfern H, Bell JJ, Barras MA, et al. Recurrent readmissions in medical patients: a prospective study. *J Hosp Med*. 2011;6(2):61–7.
- Research Manager. Available at: <http://deresearchmanager.nl/nl/home/>. Accessed 12 Jan 2016.
- Boter H, van Delden JJ, de Haan RJ, Rinkel GJ. 'Home evaluation of stroke induced aid' (HESTIA)-onderzoekgroep. A modified informed-consent procedure in which the complete information is given retrospectively: no objection from participating patients. *Ned Tijdschr Geneesk*. 2005;149(1):29–32.
- Braunholtz DA, Edwards SJ, Lilford RJ. Are randomized clinical trials good for us (in the short term)? Evidence for a "trial effect". *J Clin Epidemiol*. 2001;54(3):217–24.
- McCarney R, Warner J, Iliffe S, van Haselen R, Griffin M, Fisher P. The Hawthorne effect: a randomised, controlled trial. *BMC Med Res Methodol*. 2007;7:30.
- Kwan JL, Lo L, Sampson M, Shojania KG. Medication reconciliation during transitions of care as a patient safety strategy: a systematic review. *Ann Intern Med*. 2013;158(5 Pt 2):397–403.
- Lehnbom EC, Stewart MJ, Manias E, Westbrook JI. Impact of medication reconciliation and review on clinical outcomes. *Ann Pharmacother*. 2014;48(10):1298–312.
- Sino C, van Dooren A, Haverkamp A. Recognition of drug related problems by home healthcare employees: a Dutch observational study with self reports. *J Nurs Educ Pract*. 2013;3(8):41–9.
- Dutch Society for Cardiology. Multidisciplinary guideline for cardiac Rehabilitation 2011. Available at: <https://www.nvvc.nl/hr>. Accessed 21 June 2018.
- Goldman L, Hashimoto B, Cook EF, Loscalzo A. Comparative reproducibility and validity of systems for assessing cardiovascular functional class: advantages of a new specific activity scale. *Circulation*. 1981;64(6):1227–34.
- Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000;32(9 Suppl):S498–504.
- Holman R, Weisscher N, Glas CA, Dijkgraaf MG, Vermeulen M, de Haan RJ, et al. The Academic Medical Center linear disability score (ALDS) item bank: item response theory analysis in a mixed patient population. *Health Qual Life Outcomes*. 2005;3:83.
- Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49(2):M85–94.
- Rikli R, Jones C. Functional fitness normative scores for community residing older adults ages 60-94. *J Aging Phys Act*. 1999;7:169–79.
- Haworth JE, Moniz-Cook E, Clark AL, Wang M, Cleland JG. An evaluation of two self-report screening measures for mood in an out-patient chronic heart failure population. *Int J Geriatr Psychiatry*. 2007;22(11):1147–53.
- Koenig HG, Meador KG, Cohen HJ, Blazer DG. Self-rated depression scales and screening for major depression in the older hospitalized patient with medical illness. *J Am Geriatr Soc*. 1988;36(8):699–706.
- Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res*. 2011;20(10):1727–36.

41. National Care for the Elderly Program. Available at: <http://www.beteroud.nl/ouderen/topics-mds-database-vragenlijst.html>. Accessed 07 Nov 2017.
42. Krumholz HM, Hsieh A, Dreyer RP, Welsh J, Desai NR, Dharmarajan K. Trajectories of risk for specific readmission diagnoses after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *PLoS One*. 2016;11(10):e0160492.
43. Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, et al. Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *JAMA*. 2013; 309(4):355–63.
44. Tinetti M, Naik A, Dodson J. Moving from disease-centered to patient goals-directed care for patients with multiple chronic conditions. *JAMA Cardiol*. 2016;1(1):9–10.
45. Konrat C, Boutron I, Trinquart L, Auleley GR, Ricordeau P, Ravaud P. Underrepresentation of elderly people in randomised controlled trials. The example of trials of 4 widely prescribed drugs. *PLoS One*. 2012;7(3):e33559.
46. Rich MW, Chyun DA, Skolnick AH, Alexander KP, Forman DE, Kitzman DW, et al. Knowledge gaps in cardiovascular Care of the Older Adult Population: a scientific statement from the American Heart Association, American College of Cardiology, and American Geriatrics Society. *Circulation*. 2016;133(21): 2103–22.
47. Oerkild B, Frederiksen M, Hansen JF, Prescott E. Home-based cardiac rehabilitation is an attractive alternative to no cardiac rehabilitation for elderly patients with coronary heart disease: results from a randomised clinical trial. *BMJ Open*. 2012;2(6) <https://doi.org/10.1136/bmjopen-2012-001820>. Print 2012
48. American Association of Cardiovascular & Pulmonary Rehabilitation. Guidelines for cardiac rehabilitation and secondary prevention programs-5th edition. 5th ed: Human Kinetics; 2013.
49. Meisinger C, Stollenwerk B, Kirchberger I, Seidl H, Wende R, Kuch B, et al. Effects of a nurse-based case management compared to usual care among aged patients with myocardial infarction: results from the randomized controlled KORINNA study. *BMC Geriatr*. 2013;13:115. <https://doi.org/10.1186/1471-2318-13-115>.
50. Rao A, Suliman A, Vuik S, Aylin P, Darzi A. Outcomes of dementia: systematic review and meta-analysis of hospital administrative database studies. *Arch Gerontol Geriatr*. 2016;66:198–204.
51. Pendlebury ST, Lovett NG, Smith SC, Dutta N, Bendon C, Lloyd-Lavery A, et al. Observational, longitudinal study of delirium in consecutive unselected acute medical admissions: age-specific rates and associated factors, mortality and re-admission. *BMJ Open*. 2015;5(11):e007808. <https://doi.org/10.1136/bmjopen-2015-007808>.
52. Nguyen TN, Cumming RG, Hillmer SN. The impact of frailty on mortality, length of stay and re-hospitalisation in older patients with atrial fibrillation. *Heart Lung Circ*. 2016;25(6):551–7.
53. Kruizenga HM, Seidell JC, de Vet HC, Wierdsma NJ, Van Bokhorst-de van der Schueren MA. Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). *Clin Nutr*. 2005;24(1):75–82.
54. Katz S, Ford A, Moskowitz R, Jackson B, Jaffe M. Studies of illness in the aged. The index of Adl: a standardized measure of biological and psychosocial function. *JAMA*. 1963;185:914–9.
55. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–83.
56. McCaffery M, Beebe A. Pain: Clinical manual for nursing practice. St. Louis: C. V. Mosby; 1989.
57. Trutschnigg B, Kilgour RD, Reinglas J, Rosenthal L, Hornby L, Morais JA, et al. Precision and reliability of strength (Jamar vs. Biodex handgrip) and body composition (dual-energy X-ray absorptiometry vs. bioimpedance analysis) measurements in advanced cancer patients. *Appl Physiol Nutr Metab*. 2008; 33(6):1232–9.
58. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189–98.
59. Gual A, Segura L, Contel M, Heather N, Colom J. Audit-3 and audit-4: effectiveness of two short forms of the alcohol use disorders identification test. *Alcohol Alcohol*. 2002;37(6):591–6.
60. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport*. 1999; 70(2):113–9.
61. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14(5):377–81.
62. Bestall JC, Paul EA, Garrod R, Garnham R, Jones PW, Wedzicha JA. Usefulness of the Medical Research Council (MRC) dyspnoea scale as a measure of disability in patients with chronic obstructive pulmonary disease. *Thorax*. 1999;54(7):581–6.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

