ORIGINAL PAPER

Nagoya J. Med. Sci. **81**. 303–312, 2019
doi:10.18999/nagjms.81.2.303

Gatekeeping in an inpatient rehabilitation facility to reduce morbidity and mortality due to cardiac disease: screening program using of BNP and ECG Auto-diagnosis

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ABSTRACT

The Kaifukuki-Rehabilitation Ward (KRW) is a type of inpatient rehabilitation facility in Japan. In the KRW of our institute, mortality and frequency of emergency referrals in 2013 were rather high, 2.6% and 4.3%, respectively. We aimed to investigate the usefulness of an original gatekeeping system to reduce mortality and morbidity from cardiac complications, and to improve the quality of medical care in the KRW. A total of 370 consecutive patients admitted to the KRW of Kobayashi Memorial Hospital between 1 May 2015 and 31 March 2016 were enrolled in this prospective observational study. All patients underwent a screening evaluation in which we defined patients as being screen positive (SC-positive) if they had at least one of 20 diagnostic ECG codes and/or BNP level over 140 pg/dL at admission. A cardiologist provided weekly interventions to those among SC-positive patients who needed cardiac disease treatment during hospitalization. In all, 129 patients were classified as SC-positive (mean age 80 years, 124 [32%] male), and weekly intervention was needed in 28 patients, including start of cardiac medication in 17 cases. Mortality and frequency of emergency transfer due to cardiac disease during hospital stay were 0.3% and 0.3%, respectively. Our gatekeeping system involving a screening evaluation at admission and weekly intervention in selected patients by a cardiologist may be useful in reducing mortality and rate of transfer due to cardiac disease and may improve quality of medical care in KRWs.

Keywords: rehabilitation; BNP; screening; cardiac complications; ECG

INTRODUCTION

The Kaifukuki-Rehabilitation Ward (KRW), a Japanese facility providing intensive and comprehensive inpatient rehabilitation, was created in 2000, and KRWs have since been implemented and defined as the main type of inpatient rehabilitation facility throughout Japan.[1-3] The KRW concept was introduced by the Japanese National Insurance System to manage the increase in rehabilitative care demand stemming from rapid growth of the aged population in Japan. The number of beds in KRWs has since increased to more than 70,000 at present.[1-3]

Received: July 3, 2018; accepted: October 29, 2018

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KRWs care for the elderly during their recovery or convalescence. Patients who continue to require activities of daily living (ADLs) assistance after treatment for a specific disabling disease in an acute hospital setting are transferred to a KRW. These diseases include stroke, traumatic brain injury, spinal cord injury, acute neurological diseases, hip fracture, multiple fractures, knee replacement, hip replacement, and disuse syndrome after pneumonia or a surgical procedure.[1-3] Inpatient rehabilitation in a KRW is provided for 60 to 180 days, depending on the disease, and maximum 3 hours of rehabilitation per day are provided daily, including weekends.

A recent national survey conducted by the Kaifukuki Rehabilitation Ward Association reported a mortality of 0.5% and a frequency of transfer from a KRW to an emergency ward of up to 5.3%.[1,2] In our institute, the rates of mortality and emergency referrals in 2013 were 2.6% and 4.3%, respectively (data not published). Cardiac complications had been among the causes of mortality and of referrals to acute care hospitals in our institute before April 2014; however, at that time no weekly KRW clinical rounds were being held by a cardiologist. In April 2014, a cardiologist started clinical rounds in our KRW. At this point, we introduced an original system of "gatekeeping," which consisted of a screening system using Brain Natriuretic Peptide (BNP) and 20 diagnostic ECG codes automatically selected by a CardioStar FCP-7541 electrocardiogram (ECG) device (Fukuda Denshi, Tokyo, Japan), and weekly clinical rounds by a cardiologist for those selected by the screening. Our aim was to assess the effectiveness of this system in terms of outcome and usefulness, which we report here.

PATIENTS AND METHODS

Pilot study

Starting in June 2014, we conducted a pilot study to establish screening methods for a future prospective study. The study enrolled 51 consecutive patients with at least one of the 30 available diagnostic ECG codes and/or showing BNP level over 100 pg/dL in the screening examination at the time of admission.[4] All patients were assessed by a cardiologist to determine whether they had cardiac diseases. The data from all 51 patients were analyzed in April 2015. To obtain a positive predictive value (PPV) of more than 50% for the screening method, a cut-off BNP value of > 140 pg/dL and 20 diagnostic ECG codes (Table 1) were finally decided.

Study population

Eligible patients admitted to the KRW of Kobayashi Memorial Hospital between 1 May 2015 and 31 March 2016 were enrolled consecutively in this prospective observational study (Fig. 1). All patients underwent laboratory examinations, ECG, chest X-ray, and Hasegawa's Dementia Scale (HDS-R) test.[5] Functional Independence Measurement (FIM) score[6] was also measured, both at admission and discharge. The clinical course of each patient in the patient population from the date of admission to the date of discharge (about 3–6 months, depending on the disease) was assessed with particular attention being paid to cardiac and non-cardiac disease-related morbidity and mortality.

Gatekeeping for cardiac complications

In the screening evaluation, screening positive (SC-positive) was defined as having at least one of the 20 diagnostic ECG codes (Table 1) and/or BNP level over 140 pg/dL at admission.[7,8] The cardiologist evaluated clinical records, physical findings, laboratory data, chest X-ray, ECG, and cardiac ultrasonography (in indicated cases) of SC-positive patients and divided them into 3 categories as follows: Category 1 (C1; patients with low possibility of cardiac disease); Category

Table 1 Twenty ECG codes used for screening

Second-degree atrioventricular block (Wenckebach)
Second-degree atrioventricular block (Mobitz)
2:1 atrioventricular block
Complete atrioventricular block
Sinus arrest
Sinoatrial block
Premature atrial contraction
Blocked premature atrial contraction
Frequent premature atrial contraction
Runs of premature atrial contraction
Supraventricular tachycardia
Premature ventricular contraction
Frequent premature ventricular contraction
Runs of premature ventricular contraction
Ventricular tachycardia
Atrial fibrillation
Atrial flutter
Tachycardia
Bradycardia
QT prolongation

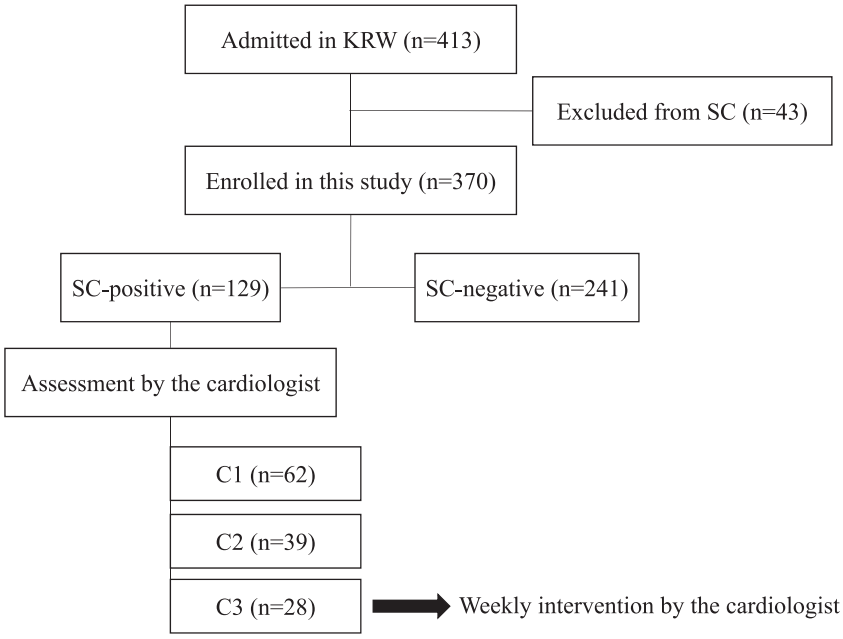

Fig. 1 Procedural Scheme of the Gatekeeping System
SC: Screening; C: Category

2 (C2; patients in stable cardiac disease condition and not needing continuous treatment by the cardiologist); Category 3 (C3; patients needing treatment such as restriction of water intake, frequent body weight check, prescription of medications, and follow up by the cardiologist during the hospital stay in the KRW). The patients in C3 were provided weekly intervention by the cardiologist for the required periods.

Analyses

Endpoints of the study were as follows: 1) overall mortality and mortality due to cardiac complications, 2) frequency of referrals to the acute care unit of our institute or to other acute cardiovascular care units, and 3) man-hours of work required by the cardiologist for this gatekeeping process.

The data for 1) and 2) were compared with data from the most recent national survey, held in 2017.[1,2,9]

Ethical aspects

The Ethics Board of Kobayashi Memorial Hospital approved all procedures (approval number: K-03); this study received ethical approval to use an opt-out methodology based on the potential benefit of the screening procedure in reducing morbidity in SC patients.

Man-hours of work by cardiologist for gatekeeping

Man-hours were calculated on the assumption that completion of the initial and second clinical rounds requires 30 minutes per patient, and that of subsequent rounds requires 15 minutes.

Statistics

Data are presented as mean ± SD, median (first to third quartile), or number (percentage). Data were calculated using Student's t-test or nonparametric Mann–Whitney U-test, as appropriate. Categorical variables were analyzed using the chi-square test or nonparametric Fisher's exact test, as appropriate. A p-value of < 0.05 was considered statistically significant.

RESULTS

Patient characteristics

A total of 370 patients were enrolled in this study (Fig. 1). The patient characteristics are shown in Table 2. The mean age was 80 years, and 124 (32%) patients were male. The percentage of cerebrovascular disease was significantly higher in SC-positive than in SC-negative patients. HDS-R and total FIM score were significantly lower in SC-positive patients. Median BNP level in SC-positive patients was 126 pg/dL.

Screening

The number of patients in C1, C2, and C3 was 62, 39, and 28, respectively. The screening results are shown in Figure 2 and Table 3. In all, 129 out of 370 patients (34.9%) were SC positive, and the PPV for the screening method (the number of C2 and C3 patients divided by the number of SC-positive patients) was 51.9%. PPV using 20 diagnostic ECG codes alone and BNP levels > 140 pg/dL alone were 49.6% and 78.3%, respectively. Cardiac comorbidities in C2 and C3 patients are shown in Figure 3. Heart failure was the most common cardiac comorbidity.

Table 2 Patient characteristics

Characteristic	All (n=370)	SC-negative (n=241)	SC-positive (n=129)	P-value
Age, years	80 ± 10	78 ± 11	83 ± 9	< 0.001
Male, n (%)	124 (34%)	77 (32%)	47 (36%)	0.27
BMI, kg/m^2	21.0 ± 3.9	21.0 ± 3.9	21.2 ± 3.9	0.65
Cerebrovascular disease, n (%)	145 (39%)	85 (35%)	60 (47%)	0.04
Orthopedic disease, n (%)	225 (61%)	156 (65%)	69 (53%)	0.04
HDS-R	17.3 ± 9.3	18.5 ± 8.9	15.1 ± 9.7	< 0.001
Motor FIM score				
On admission	42.7 ± 21.1	44.3 ± 21.3	39.8 ± 20.1	0.051
On discharge	63.1 ± 23.5	66.0 ± 22.7	57.6 ± 24.2	0.001
Total FIM score				
On admission	65.6 ± 27.9	68.0 ± 28.0	61.0 ± 27.3	0.02
On discharge	88.1 ± 31.1	92.1 ± 29.8	80.6 ± 32.4	< 0.001
Laboratory examinations				
Albumin, g/dL	3.7 ± 0.5	3.7 ± 0.4	3.6 ± 0.6	0.01
Hemoglobin, mg/dL	12.0 ± 2.0	12.0 ± 2.0	12.1 ± 2.1	0.67
Creatinine, mg/dL	0.82 ± 0.42	0.78 ± 0.40	0.89 ± 0.45	0.02
BNP, pg/mL	49 (21–115)	33 (17–64)	126 (57–211)	< 0.001
Medications				
Calcium blockers, n (%)	135 (36)	85 (35)	50 (39)	0.51
ACE inhibitors/ARBs, n (%)	102 (28)	64 (27)	38 (29)	0.55
β-blockers, n (%)	40 (11)	17 (7)	23 (18)	0.002
Diuretics, n (%)	45 (12)	18 (7)	27 (21)	< 0.001
Anticoagulants, n (%)	37 (10)	13 (5)	24 (19)	<0.0001
Antiplatelets, n (%)	121 (33)	74 (31)	47 (36)	0.26

Data are presented as mean ± SD or number (percentage). SC = screening; BMI = body mass index; HDS-R = Hasegawa's Dementia Scale; FIM = Functional Independence Measurement; BNP = brain natriuretic peptide; ACE = angiotensin-converting enzyme; ARBs = angiotensin II receptor blockers.

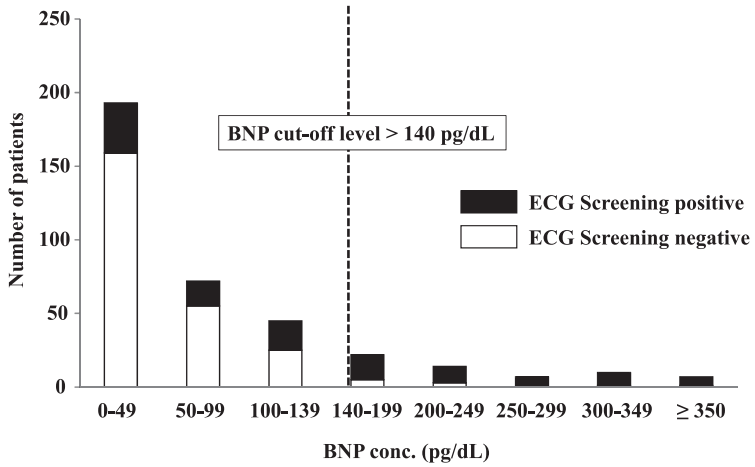

Fig. 2 Results of screening by ECG codes and/or BNP
Black column: Screening positive; White column: Screening negative

Table 3 Number of patients showing 20 ECG codes

	C1	C2	C3
Second-degree atrioventricular block (Wenckebach)	1	0	0
Second-degree atrioventricular block (Mobitz)	0	0	0
2:1 atrioventricular block	0	0	0
Complete atrioventricular block	0	0	0
Sinus arrest	0	0	0
Sinoatrial block	1	0	0
Premature atrial contraction	0	0	0
Blocked premature atrial contraction	0	0	0
Frequent premature atrial contraction	0	0	0
Runs of premature atrial contraction	0	0	0
Supraventricular tachycardia	0	0	0
Premature ventricular contraction	10	4	1
Frequent premature ventricular contraction	0	0	0
Runs of premature ventricular contraction	7	3	1
Ventricular tachycardia	0	0	0
Atrial fibrillation	14	5	12
Atrial flutter	0	0	0
Tachycardia	11	1	0
Bradycardia	2	3	2
QT prolongation	9	7	3

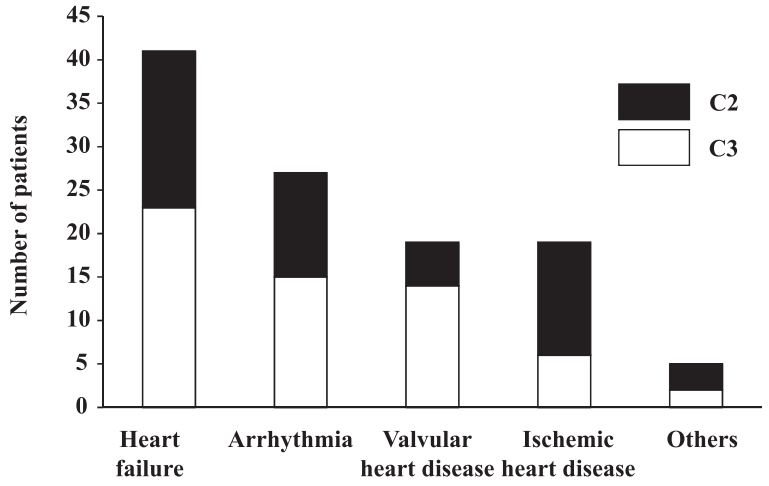

Fig. 3 Cardiac disease in C2 and C3 patients
Black column: Category 2 patients; White column: Category 3 patients

Clinical features of C1, C2, and C3 patients and the intervention provided to C3 patients

Physical findings, laboratory data, chest X-rays, and ECGs evaluated by the cardiologist demonstrated no cardiac disease or no need to intervene in C1 patients, but a need to intervene in C3 patients. This intervention included restriction of water intake to 600–1000 mL/day, weekly or more frequent body weight check, and prescription of medications. The medications are listed in Table 4.

Table 4 Medications prescribed for C3 patients

Medication	Intervention	Number of patients in C3
Calcium blockers	start medication	3
	reduction in dose or stop medication	1
	increase in dose	0
ACE inhibitors/ARBs	start medication	0
	reduction in dose or stop medication	0
	increase in dose	0
□-blockers	start medication	3
	reduction in dose or stop medication	0
	increase in dose	0
Diuretics	start medication	10
	reduction in dose or stop medication	4
	increase in dose	3
Anticoagulants	start medication	1
	reduction in dose or stop medication	0
	increase in dose	0
Antiplatelets	start medication	1
	reduction in dose or stop medication	0
	increase in dose	0

Table 5 Clinical course, morbidity, and mortality

Outcome	All (n=370)	SC-negative (n=241)	SC-positive (n=129)	P value
Death, n (%)	7 (1.9%)	1 (0.4%)	6 (4.7%)	0.008
Cardiac disease, n (%)	1 (0.3%)	0 (0%)	1 (0.8%)	0.35
Non cardiac disease, n (%)	6 (1.6%)	1 (0.4%)	5 (3.9%)	0.03
Transfer, n (%)	13 (3.5%)	7 (2.9%)	6 (4.7%)	0.38
Cardiac disease, n (%)	1 (0.3%)	0 (0%)	1 (0.8%)	0.33
Non cardiac disease, n (%)	12 (3.2%)	7 (2.9%)	5 (3.9%)	0.77
Discharge on schedule, n (%)	350 (94.6%)	233 (97%)	117 (91%)	0.03

Clinical course and prognosis

Clinical course and prognosis of the 370 patients are shown in Table 5. For various reasons, 13 patients (3.5%) were referred to acute care units of other hospitals. One C1 patient (0.3%) with acute myocardial infarction that occurred on the 14th day of hospitalization was transferred to the CCU of another hospital; however, the other 12 patients were referred to acute care units for non-cardiac reasons (Table 5).

Among 7 patients who died in-hospital (1.9%), one C3 patient died of arrhythmia. Treatment in the CCU of another hospital was recommended; instead, the patient and patient's family chose palliative care owing to the patient's advanced age (89 years) and poor performance status. The other 6 patients died of non-cardiac diseases. Mortality due to cardiac disease was 0.3% (Table 5).

Man-hours of work by cardiologist for gatekeeping

Among C3 patients, the total number of clinical rounds from admission to discharge was 3 to 5 in 5 patients, 6 to 9 in 11 patients, and 10 to 15 in 12 patients. The number of man-hours of cardiologist labor was 75.5.

DISCUSSION

A national survey previously conducted by the Kaifukuki Rehabilitation Association reported rather high mortality and morbidity in KRWs: reported mortality, frequency of patients moving from KRW to the acute care unit of the same hospital, and that of referral to an acute care unit of other acute hospital were 7.2%, 3.8%, and 7.1% respectively.[1] The reported mortality rate and frequency of transfer from KRW to emergency wards were improved in 2017 to 0.5% and to 5.3%, respectively.[1,2]

In our institute, mortality rate and frequency of emergency referrals in 507 KRW patients in 2013 were 2.6% (0.8% due to cardiac disease and 1.8% due to non-cardiac diseases) and 4.3% (0.8% cardiac and 3.6% non-cardiac disease), respectively (data not published) before the introduction of the gatekeeping system. After the introduction of gatekeeping using our screening methods and intervention by the cardiologist in 7.6% of our patients (the number of C3 patients divided by 370 enrolled patients), mortality rate and frequency of referrals for cardiac complications to other acute hospitals decreased to 0.3% (one elderly patient who received only palliative care) and 0.3% (one patient who had acute myocardial infarction after the screening), respectively. Although overall mortality in our institute was still higher, the frequency of emergency transfer

was the same or a little lower than that reported in the national survey.[1,2]

It has been reported that pre-existing heart failure is a negative prognostic factor for pulmonary disease.[10] In 13 out of 28 C3 patients, diuretics were newly started or increased in dose. In 25 of 28 C3 patients, diagnoses of cardiac disease, including heart failure, were not recorded on their medical referral forms. The usefulness of our gatekeeping system may be partly attributed to intervention by the cardiologist in the absence of a clear diagnosis of cardiac disease at admission.

BNP is produced by heart ventricles and useful in ruling out a diagnosis of heart failure.[4,9,11] Before the start of this study, a retrospective evaluation of KRW patients with known BNP value at admission, which had been examined by one of the attending physicians as a clinical practice, was performed. The results were suggestive of the usefulness of BNP screening for cardiac comorbidity. When we started this study, BNP measurement at admission had been included in the critical pathways in KRWs.

There have been several cut-off values of BNP, for example BNP < 100 pg/mL, based on studies conducted in young and symptomatic patients.[7,11] These data should be interpreted with caution when applied to BNP levels in elderly and asymptomatic patients. Therefore, the design of our screening methods was based on the results of a small pilot study. The positivity rate and PPV of screening (the number of C2 and C3 patients divided by 370 enrolled patients) were 34.9% and 51.9% respectively. Finally, our cardiologist treated 7.6% of the enrolled 370 patients in the KRW. Considering the present study positivity rate, PPV for screening, and mortality due to cardiac complications, our methods of screening using the cut-off level of BNP (BNP > 140 pg/dL) and 20 automatically selected diagnostic ECG codes may be an acceptable gatekeeping approach to delivery of medical care for cardiac complications in patients referred to KRWs. The present study notably demonstrated that attending physicians in KRWs need to pay attention to possible “hidden” heart failure and valve diseases not previously revealed in neurosurgical units or orthopedic care units.

Many rehabilitation hospitals with KRWs in Japan do not have a full-time cardiologist available to take care of or treat KRW patients, owing to the high demand for registered cardiologists in acute cardiac care units and the limited number of cardiac care specialists. In this study, the gatekeeping duties of our cardiologist required 75.5 man-hours, which is manageable in most rehabilitation hospitals with KRWs. Our gatekeeping process involving screening followed by weekly interventions to treat cardiac complications for selected patients may be useful to maintain the quality of medical care for cardiac diseases in facilities (subacute care units or rehabilitation hospitals with KRWs) lacking a full-time cardiologist.

Improvement in ADLs is the most important yardstick of the quality of rehabilitation services in a KRW. In the present study, C2 and C3 patients as well as SC-negative and C1 patients admitted to KRWs showed significant FIM gains after comprehensive rehabilitation and cardiac intervention. Notably, our gatekeeping system enabled physiotherapists to provide the necessary and sufficient rehabilitation prescribed by specialists to SC-negative and C1 patients, and appropriate rehabilitation to C2 and C3 patients under the supervision of the cardiologist. This may account for the good rehabilitative outcomes noted in the C2 and C3 patients.

CONCLUSION

Our screening program used BNP > 140 pg/dL and 20 diagnostic ECG codes to identify and to select candidates for weekly intervention by a cardiologist. Weekly intervention by a cardiologist associated with our gatekeeping screening program may be useful to reduce morbidity and mortality due to cardiac disease, and to improve quality of medical care in KRWs.

ACKNOWLEDGEMENTS

The authors heartedly express their thanks to Dr. Takehiko Kobayashi, CEO of Kobayashi Health Care System, for his encouragement and kind support for this study.

CONFLICT OF INTEREST

All authors have nothing to disclose.

REFERENCES

1. Kaifukuki Rehabilitation Ward Association OWL; 20 May 2017; http://www.rehabili.jp/eng/eng_page.htlm. Accessed May 20, 2017.
2. Kaifukuki Rehabilitation Ward Association OWL; 4 March 2018; http://www.rehabili.jp/eng/eng_page.htlm. Accessed March 4, 2018.
3. Watanabe S. Current state and future challenges facing Kaifukuki Rehabilitation Wards [in Japanese]. *Jpn J Rehabil Med*. 2009;46:799–807.
4. Prahash A. B-Type Natriuretic Peptide: A Diagnostic, Prognostic, and Therapeutic Tool in Heart Failure. *Am J Crit Care*. 2004,13(1):46–53.
5. Kim KW, Lee DY, Jhoo JH, et al. Diagnostic accuracy of mini-mental status examination and revised Hasegawa Dementia Scale for Alzheimer's disease. *Dement Geriatr Cogn Disord*. 2005;19(5–6):32430.
6. Chumney D, Nollinger K, Shesko K, Skop K, Spencer M, Newton RA. Ability of Functional Independence Measure to accurately predict functional outcome of stroke-specific population: systematic review. *J Rehab Res Devel*. 2010;47(1):17–30.
7. Tsuchida K, Tanabe K Plasma brain natriuretic peptide concentrations and the risk of cardiovascular events and death in general practice. *J Cardiol*. 2008;52:212–223.
8. Maisel AS, Krishnaswamy P, Nowak RM, et al. Rapid measurement of B-type natriuretic peptide in the emergency diagnosis of heart failure. *N Engl J Med*. 2002;347:161–167.
9. Shiba A, Kurata H, Sasaki H, Naoe M, Kunitomo K, Yamakami A. N-terminal pro-brain natriuretic peptide level as a prognostic predictor in elderly patients in a convalescent rehabilitation ward. *Prog Rehabil Med*. 2017;2:1–11.
10. Thomsen RW, Kasatpibal N, Riis A, Nørgaard M, Sørensen HT. The Impact of Pre-existing Heart Failure on Pneumonia Prognosis: Population-based Cohort Study. *J Gen Intern Med*. 2008,23(9):1407–1413.
11. Harada E, Mizuno Y, Kugimiya F, et al. B-type natriuretic peptide in heart failure with preserved ejection fraction relevance to age-related left ventricular modeling in Japanese. *Cir J*. 2017;81(7):1006–1013.