BNP TESTING AND THE ACCURACY OF HEART FAILURE DIAGNOSIS
IN THE EMERGENCY DEPARTMENT

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Abstract

**Background**: It is often difficult to diagnose heart failure (HF) accurately in patients presenting with dyspnoea to the emergency department (ED). This study assessed whether B-type Natriuretic Peptide (BNP) testing in these patients improved the accuracy of HF diagnosis.

**Methods and Results**: Patients presenting to The Alfred and The Northern Hospital EDs with a chief complaint of dyspnoea were enrolled prospectively from August 2005 to April 2007. Patients were randomly allocated to have BNP levels tested or not. The diagnostic “gold” standard for HF was determined by one cardiologist and one emergency or respiratory physician who, blinded to the BNP result, independently reviewed all available information.

The ED diagnosis of HF in the non BNP group, showed a sensitivity, specificity and accuracy of 65%, 92% and 81% respectively. The BNP group had a similar sensitivity, specificity and accuracy of 66%, 90% and 78% respectively for the diagnosis of HF in the ED. There was no significant difference between the BNP and non BNP groups in any of the measures of diagnostic accuracy for HF.

**Conclusion**: In the clinical setting of emergency departments, availability of BNP levels did not significantly improve the accuracy of a diagnosis of HF.

**Key words**: heart failure, BNP, dyspnoea, emergency, diagnosis

**Clinical Trial Registration Information**: www.clinicaltrial.gov, Identifier: NCT00163709
Introduction

The incidence of heart failure (HF) is reaching epidemic proportions in the Western world\textsuperscript{1}. With an ageing population and greater survival from disease processes leading to HF, the burden of this disease on the health care system will only increase in the future\textsuperscript{2}.

Most patients with acute HF syndromes present to hospital through the ED\textsuperscript{3}. Their most common presenting complaint is dyspnoea\textsuperscript{4}. However, the differential diagnosis of dyspnoea is myriad and includes pulmonary diseases which often co-exist in patients with HF\textsuperscript{5}. Studies examining the accuracy of ED diagnosis of HF using traditional means such as history, examination, ElectroCardioGraphy (ECG) and Chest X-ray (CXR) have found varying levels of accuracy resulting in misdiagnosis, delays to treatment and increased morbidity and mortality\textsuperscript{6-9}.

B-type Natriuretic peptide (BNP) is a cardiac neurohormone primarily secreted from cardiac ventricles\textsuperscript{10}. BNP levels rise in patients with HF\textsuperscript{11-13}. Since the development of rapid bedside investigations to test BNP levels, BNP has been studied widely as a potential tool to enhance the accuracy of HF diagnosis\textsuperscript{14-16}. These studies show that BNP levels are significantly higher in patients with dyspnoea due to HF than from another cause. Further, BNP levels show a higher accuracy in diagnosing HF than clinical judgement\textsuperscript{17-19}. Consequently, several of these studies have extrapolated through statistical analysis that theoretically, adding a BNP test to other clinical measures could improve the accuracy of HF diagnosis\textsuperscript{17-20}. However, as yet no study has assessed the impact of real time BNP measurement on the accuracy of HF diagnosis in the ED in a randomised clinical trial.
The European Society of Cardiology guidelines for heart failure recommend use of the BNP test to rule out HF\textsuperscript{21} and the American College of Cardiology suggests use of the BNP test in the urgent care setting where the diagnosis of HF is uncertain\textsuperscript{22}. Recently, BNP testing for HF diagnosis in the emergency setting received government funding in Australia\textsuperscript{23}. Most available literature suggests a cut off point of 100pg/ml for the BNP test, so that at a value <100pg/ml HF is unlikely\textsuperscript{14-18}. Mueller et al showed that in Switzerland, patients who had BNP testing in ED had earlier initiation of appropriate treatment, decreased hospital and ICU admission rates, earlier discharge and decreased cost of treatment\textsuperscript{24}. In contrast, the randomised controlled trial BNP in shortness of breath (SOB) study conducted in Australia by Schneider \textit{et al} showed that BNP testing in dyspnoeic patients presenting to the ED did not improve hospital admission rates, length of hospital stay or management in ED\textsuperscript{25}.

This study analyses data from the BNP in SOB multicentre study\textsuperscript{25}. With several studies demonstrating a theoretical improvement to the accuracy of HF diagnosis in the ED with BNP testing\textsuperscript{17-20}, we hypothesised that real time BNP testing in the ED would improve the accuracy of the clinical diagnosis of HF.

\section*{Methods}

\subsection*{Study Setting}

A prospective, randomised, controlled, single blind study “The BNP in SOB Study” conducted in the EDs of The Alfred Hospital (tertiary referral centre, 45 000 patient attendances per year) and The Northern Hospital (metropolitan hospital, 70 000 patient attendances per year) Victoria, Australia was undertaken between
August 2005 and April 2007. Data from this study was retrospectively reviewed for this paper.

**Study Design and Consent**

Eligible patients were enrolled in the study by ED staff at presentation. They were randomised either to the BNP group (BNP levels were tested) or the non BNP group (BNP levels not tested – control group) before consent. Randomisation was by random numbers (from computer generated random number tables) concealed in an envelope. The randomisation was stratified by site. A trained research assistant gained from the patient or their next of kin within 24 hours of admission.

Entry criteria included an Australian Triage Scale of 1-3 (illness acuity requiring assessment by a doctor immediately to within 30 minutes of arrival), in patients with a primary presenting complaint of dyspnoea. Exclusion criteria were: <40 years, a traumatic cause of dyspnoea, cardiogenic shock, a serum creatinine >250µmol/L and patients who were transferred to another hospital within 24 hours of presentation.

All patients underwent routine clinical examination by a doctor (ED registrar or consultant, or ED resident supervised by a registrar or consultant) and routine investigations including blood tests, CXR and ECG. When possible, a TransThoracic Echo (TTE) and a Pulmonary Function Test (PFT) were performed within 30 days of presentation.

Doctors and nurses involved in patient care in the ED were given four education sessions during the study period by emergency doctors involved in the study. These education sessions familiarised staff with BNP, its role in the diagnosis of HF and the current literature in the field. Further, each treating doctor of an enrolled patient received a written guideline on the treatment of acute HF and
chronic obstructive pulmonary disease and the BNP nomogram (developed by McCullough et al\textsuperscript{17}) with an explanation on how to use it. Doctors were educated that dyspnoeic patients with a BNP value <100pg/ml were unlikely to have HF as the primary diagnosis and that dyspnoeic patients with a BNP value >500pg/ml were likely to have HF as the primary diagnosis.

**Probability of HF**

The treating emergency doctor for each patient was asked to assign a probability of HF as the cause of dyspnoea after initial assessment of the patient and preliminary investigations, but without the BNP test. The probabilities were divided into 5 categories: 0%, 1-25%, 26-50%, 51-75% and 76-100%.

**Disposition Diagnosis**

The disposition diagnosis (the diagnosis at the time of discharge from the ED; after all investigations, including the BNP test, and treatment in the ED) was recorded for the BNP and non BNP groups. Where the patient was admitted, the disposition diagnosis was that recorded by the admitting unit registrar or resident derived from the emergency doctor’s diagnosis. Where the patient was discharged from the ED, the disposition diagnosis was the emergency doctor’s final diagnosis.

Baseline demographics, clinical information from the current and relevant previous presentations and follow-up investigations (TTE and PFT) were gathered by trained research assistants.

**BNP Testing**

All patients had a 10ml sample of blood collected in an EDTA tube upon presentation to the ED. Only patients who were randomised to the BNP group had a BNP level tested and the result available on the computer. The BNP level was measured on plasma using the Abbott AxSYM MEIA Automated immunoassay
(Abbott, USA). The measurable range of the BNP assay is 15 – 4,000pg/ml with an on-board 1 in 5 dilution to take the upper limit to 20,000pg/ml. The BNP levels were available to medical staff within one hour of collection. This test is calibrated against the Triage B-Type Natriuretic Peptide test (Biosite Inc., San Diego, California). It performs well in the clinical setting with an area under the curve comparable to published data.\(^2\)

**Reviewer Adjudicated Diagnosis (Final Diagnosis)**

The final diagnosis of HF was made by one emergency physician and one cardiologist who independently reviewed all available information including case notes, blood tests, ECG and CXR reports, response to treatment, TTE and PFT results. The reviewing physician was blinded to the BNP result. The reviewers received a definition of HF based on the European Society of Cardiology Working Group on HF diagnostic criteria.\(^2\) and an algorithm for the diagnosis of HF. Patients were classified into 3 categories for the main cause of dyspnoea: 1) HF in isolation, 2) HF in conjunction with another diagnosis and 3) no HF. For this analysis, patients in categories 1 and 2 were grouped together so that the two categories for the final diagnosis were HF and no HF. Where the two reviewers agreed, the diagnosis was taken as the final diagnosis for the patient. Where they disagreed, a third physician (cardiology, respiratory or emergency) reviewed all available data (blinded to the BNP test) and made a diagnosis, which was then used as the final diagnosis.

**Data and Statistical Analysis**

Statistical analyses were performed using Stata version 9.0 (Stata Corporation, College Station, Tx, USA). A p value less than 0.05 was considered to indicate statistical significance. Baseline characteristics are reported in counts and
proportions or mean ± SD as appropriate. Univariate comparisons were made with \( \chi^2 \) test, 2-sample t test, or the Wilcoxon 2-sample test as appropriate.

The disposition diagnosis and final diagnosis were divided into 2 groups: HF or no HF. Statistics were computed from 2x2 tables and reported as accuracy (true positive and true negative cases as a proportion of the total), sensitivity and specificity.

Receiver-operating characteristic (ROC) curve analysis was performed for BNP levels and the emergency doctors’ assessment of the probability of HF with the final diagnosis as the reference standard. These ROC curves were compared using the area under the curve (AUC). An ROC curve was generated through logistic regression using the BNP group doctors’ assessment of the probability of HF and the BNP values as predictors of a final diagnosis of HF. This combined ROC curve was compared to the ROC curves of the probability of HF and BNP values to determine whether the BNP test would significantly improve the diagnostic quality of the doctor’s assessment of the probability of HF.

Agreement between the two reviewers for the final diagnosis was quantified using Cohen’s \( \kappa \) statistic.

**Ethics**

Ethics approval for this study was granted by The Alfred Ethics Committee, The Northern Hospital Ethics Committee and The Monash University Standing Committee on Ethics in Research Involving Humans. The investigation conforms to the principles outlined in the Declaration of Helsinki. This study was registered on the Registry of the US National Institutes of Health (www.clinicaltrial.gov), registration number NCT00163709.
Results

Study Cohort and Baseline Characteristics

799 patients were recruited. 187 patients were excluded due to refusal of consent (n=135), exclusion criteria (n=20), transfer within 24 hours (n=19) or incomplete sample collection (n=13). Of the final cohort of 612 patients, 306 patients were randomised to have the BNP test (BNP group) and 306 patients not to have BNP test (non BNP group).

The baseline demographic and clinical characteristics for the BNP and non BNP groups were similar except patients in the BNP group were more likely to have a history of orthopnoea and a past history of HF and hypertension (p=0.005, p=0.03 and p=0.01 respectively; table 1). Adjusting for a past history of HF through logistic regression did not significantly alter the results.

Of the study cohort of 612 patients, 45% (n = 274) had a final diagnosis of HF: 48% (n = 148) in the BNP group and 41% (n = 126) in the non BNP group.

Reviewers 1 and 2 agreed on the final diagnosis in 553 (90%) patients. A third reviewer assessed the remaining 59 patients’ data to determine the final diagnosis. Exclusion of these patients from the final analysis did not significantly alter the results. Agreement for the final diagnosis between reviewer 1 and reviewer 2 in the BNP and non BNP groups was $\kappa = 0.79$ (95%CI: 0.78-0.83) and $\kappa = 0.82$ (95%CI: 0.78-0.86) respectively. Table 2 shows characteristics of patients with a final diagnosis of HF and no HF.

In the BNP group, 10 patients did not have BNP levels tested due to laboratory error. We included these patients in the analysis. Their exclusion did not significantly alter the results.
Impact of the BNP Test on the Accuracy of the Disposition Diagnosis

In the BNP group, the accuracy of the disposition diagnosis of HF was 78%, with a sensitivity of 66% (95% Confidence Interval (CI): 57%-73%) and a specificity of 90% (95%CI: 84%-94%). In the non BNP group, the accuracy of the disposition diagnosis of HF was 81% with a sensitivity of 65% (95%CI: 56%-73%) and a specificity of 92% (95%CI: 87%-96%) (Figure 1).

In the BNP group, analysis of the disposition diagnosis against the final diagnosis of the subgroup of patients with a BNP value <100pg/ml (n=89) shows that a majority (n=75, 84%) received an accurate disposition diagnosis of no HF. In the subgroup with a BNP value >500pg/ml (n=127), 74 patients had an accurate disposition diagnosis of HF and 18 had an accurate disposition diagnosis of no HF. However, 31 patients (24%) were under-diagnosed as having no HF and only 4 patients over-diagnosed as having HF.

The accuracy of the disposition diagnosis in patients given an intermediate probability of HF (26-75%) by the emergency doctor (n = 131) was similar in the BNP and non BNP groups. In the BNP group (n = 69), the disposition diagnosis had an accuracy, sensitivity and specificity of 64%, 66% and 58% respectively and in the non BNP group (n = 62), the disposition diagnosis had an accuracy, sensitivity and specificity of 65%, 67% and 58% respectively.

Accuracy of the BNP Test

At a cut off of 101pg/ml the accuracy, sensitivity and specificity of the BNP test was 71%, 92%, 51% respectively. The optimum cut off point for the BNP test in our study, derived from the ROC curve of the BNP test against the final diagnosis of HF was 265pg/ml: accuracy 82%, sensitivity 83% and specificity 81%.
The overall diagnostic accuracy of the BNP test in the two groups with a BNP value <100pg/ml (HF unlikely) and >500pg/ml (HF likely) was 84%. These two groups combined encompassed 71% of the study cohort.

**Reference Range of the BNP Test and the BNP levels of our participants.**

In our study, the range of BNP values was 4-10565pg/ml. The cohort with a final diagnosis of HF (n=148) had a median BNP value of 830pg/ml (interquartile range: 391-1425pg/ml). 92% (n = 136) of these patients had a BNP value >100pg/ml. Patients with a final diagnosis of HF and a BNP value <100pg/ml (n = 12) had a mean age of 66 (range 55-80) with an even distribution of gender. Half the patients had a past history of ischaemic heart disease and hypertension and more than half had a past history of heart failure. TTE was available in 8 patients and of these 7 patients had a normal ejection fraction, however, interestingly half of these patients (n = 4) had evidence of diastolic dysfunction on TTE.

The cohort of patients with a final diagnosis of no HF (n=158) had a median BNP value of 99pg/ml (interquartile range: 46-180pg/ml). Only 49% (n = 77) of these patients had a BNP value <100pg/ml.

**The probability of HF**

A probability of HF was recorded by the emergency doctor after initial assessment but prior to the BNP result for 593 patients. The ROC curves of the probability of HF for the whole group had an AUC of 0.86 (95%CI: 0.83-0.89). The BNP values ROC curve had an AUC of 0.87 (95%CI: 0.83-0.91). There was no significant difference between the BNP group probability of HF ROC curve AUC (0.88, 95%CI: 0.84-0.92) and the AUC of the BNP values (p = 0.73).

The ROC curves of the BNP values and the BNP group probability of HF were combined statistically and had an AUC of 0.93 (95%CI: 0.90-0.96) significantly better.
than the AUCs of the BNP values or the BNP group probability of HF ROC curves individually, p < 0.001 (figure 2).

Discussion

This is the first randomised controlled study to assess the impact of real time BNP testing on the accuracy of HF diagnosis in the clinical setting within two busy Australian EDs. Although our study found that BNP values were significantly higher in patients with a final diagnosis of HF and that the BNP test had a high level of accuracy for the diagnosis of HF, in the real life setting, adding the BNP test to clinical judgement did not significantly add to the accuracy of the disposition diagnosis of HF.

Consistent with other studies, we found that patients with a final diagnosis of HF had significantly higher BNP levels than patients with a final diagnosis of no HF14-16. However, the median BNP value of our patients with a final diagnosis of HF and patients with a final diagnosis of no HF was higher than previously reported at 830pg/ml and 99pg/ml respectively14-16. Also we found that in our study population, the recommended cut off point of 100pg/ml had a much lower specificity than reported in other studies17,18. We found similar accuracy, sensitivity and specificity levels to those reported by Maisel et al18 at the optimum cut off point of 265pg/ml. This reflects the findings by Edmin et al28 that BNP cut off concentrations are greatly dependent on the study population and the type of BNP assay used.

There are three main characteristics of our study population which may have led to higher BNP levels. 1) Although BNP levels have been shown to be higher in patients with myocardial ischaemia29, we did not exclude these patients from the study population as acute HF may often co-exist with myocardial ischaemia in
patients presenting to the ED. 2) Our cohort of patients had a significant level of co-
morbidity and was generally older and more acutely unwell than the patients
investigated in other studies. It is well known that BNP levels increase with age. 3) In
the group with a final diagnosis of no HF, patients who had a past history of HF were
not separated out. Patients with a past history of HF have been shown to have
higher baseline BNP levels\textsuperscript{18}. However, this is a confounder that is frequently
encountered in the real life setting. This variability in BNP concentrations between
different patient populations may be detrimental to the usefulness of the test in aiding
diagnosis in the clinical setting.

Similar to the studies by McCullough \textit{et al}\textsuperscript{17} and Green \textit{et al}\textsuperscript{19}, in theory, when
the BNP test is statistically combined with the emergency doctors’ assessment of the
probability of HF, the accuracy of the doctors’ assessment improves significantly. In
our study, if the emergency doctor had adhered strictly to the diagnostic
recommendations and diagnosed all patients with a BNP value <100pg/ml as no HF
and >500pg/ml as having HF, the disposition diagnosis accuracy would not have
improved greatly (84%) and approximately 30% of patients would not have been
classified. However, in the subgroup with a BNP value >500pg/ml, more patients with
HF would have been identified.

In the real life clinical setting, this randomised controlled study, found that
there was no significant difference in accuracy, sensitivity or specificity of the
disposition diagnosis with or without the BNP test. This is consistent with the
primary results of the BNP in SOB study which showed that BNP testing did not alter
hospital admission rates, length of stay or 30day mortality\textsuperscript{25}.

The study cohort of patients was drawn from EDs staffed by senior doctors
experienced in emergency medicine with a high level of supervision of junior doctors.
Consistent with this, the assessment of the probability of HF by the emergency doctor and the disposition diagnosis had a higher accuracy than described by McCullough et al. Further, BNP levels may be elevated in several conditions such as a past history of heart failure, chronic renal failure, myocardial ischaemia, pulmonary embolus and rapid atrial fibrillation. Some of these conditions may co-exist with HF in a patient presenting with dyspnoea to the ED.

The main strength of this study is that the impact of the BNP test on the accuracy of the diagnosis of HF was assessed in the clinical setting in real time through a randomised controlled trial. In this way, it was possible to elucidate whether the BNP test improves the accuracy of HF diagnosis in the ED. Further, this study was able to define an optimum cut off point for the BNP test in the diagnosis of HF in an Australian population of patients presenting to a tertiary referral and a metropolitan hospital.

One of the limitations of our study is that there were more patients in the BNP group with a past history of hypertension and HF and a symptom of orthopnoea. However, adjusting for these patients did not alter the results of the study. Another limitation is that there is no definitive test or robust clinical definition of HF: it is a syndrome characterised by a constellation of symptoms and signs. However, we counteracted this by providing each reviewer with a standardised definition and an algorithm for the diagnosis of acute HF. Reviewers were blinded to the BNP result. There was a high level of agreement between reviewers.

BNP levels would have been influenced by acute myocardial ischemia and a past history of HF. These have been excluded in some studies. As these problems are encountered in the real life setting we did not attempt to control for these
confounders. Similarly, we did not use age adjusted partition values given that the BNP nomogram by McCullough et al\textsuperscript{17} does not stratify the BNP values by age.

**Conclusions**

This study showed that BNP levels were significantly higher in patients with HF and the BNP test had a high level of accuracy in the diagnosis of HF. In the clinical setting, however, BNP testing did not add to the accuracy of the disposition diagnosis of HF in patients presenting with dyspnoea to the ED.

In the future, the development of more specific BNP nomograms adjusted to variables affecting BNP values such as age, gender, ethnicity and a past history of HF, may make the BNP test more useful in HF diagnosis in the ED.

**Funding source**

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**Disclosures**

There is no conflict to disclose.
Reference


Figure Legends

Table 1: Patient Baseline Characteristics

Table 2: Clinical Characteristics of Patients with a Final Diagnosis of HF and No HF

Figure 1: Accuracy of the Disposition Diagnosis for HF against the Final Diagnosis in the BNP and non BNP groups

Figure 2: ROC curves for the BNP values (bnpvalue), the BNP group doctors’ assessment of the probability of HF (ccfprob0), and the combined ROC curve
**Table 1**

**Patient Baseline Characteristics**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>BNP group n=306</th>
<th>Non BNP group n=306</th>
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</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>74 ± 11</td>
<td>73 ± 11</td>
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<tr>
<td>Range</td>
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<td>49-98</td>
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<td><strong>Sex, n (%)</strong></td>
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<td></td>
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<tr>
<td>Male</td>
<td>166 (54)</td>
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<tr>
<td>Female</td>
<td>140 (46)</td>
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<tr>
<td><strong>History, n (%)</strong></td>
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<tr>
<td>COPD*/Asthma</td>
<td>202 (66)</td>
<td>186 (61)</td>
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<tr>
<td>Hypertension</td>
<td>170 (56)</td>
<td>138 (45)</td>
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<tr>
<td>Ischaemic Heart Disease</td>
<td>129 (42)</td>
<td>124 (41)</td>
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<tr>
<td>HF</td>
<td>123 (40)</td>
<td>97 (32)</td>
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<tr>
<td>Atrial Fibrillation</td>
<td>93 (30)</td>
<td>79 (26)</td>
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<tr>
<td>Diabetes Mellitus</td>
<td>61 (20)</td>
<td>60 (20)</td>
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<tr>
<td>Renal failure</td>
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<tr>
<td><strong>Symptoms, n (%)</strong></td>
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<td>Cough</td>
<td>153 (50)</td>
<td>152 (50)</td>
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<tr>
<td>Sputum</td>
<td>79 (26)</td>
<td>81 (26)</td>
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<tr>
<td>Orthopnoea</td>
<td>76 (25)</td>
<td>48 (16)</td>
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<tr>
<td>Swelling of ankles</td>
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<td>54 (18)</td>
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<tr>
<td>Fever</td>
<td>36 (12)</td>
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<tr>
<td><strong>Signs, n (%)</strong></td>
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<tr>
<td>Crackles</td>
<td>168 (55)</td>
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<tr>
<td>Wheeze</td>
<td>84 (27)</td>
<td>86 (28)</td>
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<tr>
<td>Raised JVP†</td>
<td>81 (28)</td>
<td>88 (30)</td>
</tr>
<tr>
<td>Displaced Apex Beat</td>
<td>54 (19)</td>
<td>39 (13)</td>
</tr>
<tr>
<td>Third Heart Sound</td>
<td>5 (2)</td>
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<td><strong>Vital signs, mean ± SD (range)</strong></td>
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<tr>
<td>Systolic blood pressure</td>
<td>143 ± 30 (70-269)</td>
<td>141 ± 28 (70-240)</td>
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<tr>
<td>Diastolic blood pressure</td>
<td>73 ± 18 (30-155)</td>
<td>73 ± 18 (23-140)</td>
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<tr>
<td>Heart rate, bpm‡</td>
<td>95 ± 24 (46-178)</td>
<td>97 ± 23 (50-175)</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>25 ± 6 (6-46)</td>
<td>25 ± 8 (12-62)</td>
</tr>
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<td><strong>Investigations, n (%)</strong></td>
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<tr>
<td>Chest X ray</td>
<td>283 (92)</td>
<td>282 (92)</td>
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<tr>
<td>Electrocardiogram</td>
<td>236 (77)</td>
<td>236 (77)</td>
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<td><strong>Final diagnosis of HF, n (%)</strong></td>
<td>148 (48)</td>
<td>126 (41)</td>
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<tr>
<td><strong>Number of admission:</strong></td>
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<tr>
<td>Admitted, n (%)</td>
<td>262 (86)</td>
<td>265 (87)</td>
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*COPD: Chronic Obstructive Pulmonary Disease
† JVP: Jugular Venous Pressure
‡ bpm: beats per minute
<table>
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<tr>
<th>Characteristics</th>
<th>HF group</th>
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<th>p-value</th>
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<tr>
<td>Patient number (%)</td>
<td>274 (45)</td>
<td>338 (55)</td>
<td></td>
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<td>Age, mean ± SD, (range), years</td>
<td>77± 11 (45-98)</td>
<td>71±11 (40-94)</td>
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<td>BNP pg/ml, median (IQR)</td>
<td>830 (391-1425)</td>
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<td>Medical History, n (%)</td>
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<td>Hypertension</td>
<td>173 (63)</td>
<td>135 (40)</td>
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<tr>
<td>Heart Failure</td>
<td>163 (60)</td>
<td>57 (17)</td>
<td>&lt;0.001</td>
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<tr>
<td>Ischaemic Heart Disease</td>
<td>162 (59)</td>
<td>91 (27)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>110 (40)</td>
<td>62 (18)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>COPD*</td>
<td>156 (57)</td>
<td>232 (69)</td>
<td>0.003</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>63 (23)</td>
<td>58 (17)</td>
<td>0.072</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>49 (18)</td>
<td>20 (6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Symptoms, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthopnoea</td>
<td>86 (32)</td>
<td>38 (11)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cough</td>
<td>111 (41)</td>
<td>194 (57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sputum</td>
<td>49 (18)</td>
<td>111 (34)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fever</td>
<td>24 (9)</td>
<td>56 (17)</td>
<td>0.004</td>
</tr>
<tr>
<td>Swelling of Ankles</td>
<td>63 (23)</td>
<td>32 (9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Signs, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crackles on auscultation</td>
<td>209 (74)</td>
<td>137 (40)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Raised JVP†</td>
<td>136 (52)</td>
<td>33 (10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Wheeze on auscultation</td>
<td>64 (24)</td>
<td>106 (32)</td>
<td>0.028</td>
</tr>
<tr>
<td>Displaced Apex Beat</td>
<td>68 (27)</td>
<td>22 (7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CXR findings, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Venous Congestion</td>
<td>114 (42)</td>
<td>13 (4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Kerley B lines</td>
<td>10 (4)</td>
<td>1 (0.3)</td>
<td>0.002</td>
</tr>
<tr>
<td>ECG findings, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>64 (24)</td>
<td>27 (8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sinus tachycardia</td>
<td>37 (14)</td>
<td>86 (25)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Statistical analysis by Pearson chi-square test
* Chronic Obstructive Pulmonary Disease
† JVP: Jugular Venous Pressure
Figure 1
Accuracy of the Disposition Diagnosis for HF against the Final Diagnosis in the BNP and non BNP groups
Figure 2
ROC curves for the BNP values (bnpvalue), the BNP group doctors’ assessment of the probability of HF (ccfprob0), and the combined ROC curve
BNP Testing and the Accuracy of Heart Failure Diagnosis in the Emergency Department

Amaali Lokuge, Louisa L. Lam, Peter Cameron, Henry Krum, de Villiers Smit, Adam Bystrzycki, Matthew T. Naughton, David Eccleston, Genevieve Flannery, Jacob Federman and Hans G. Schneider

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