



Role of Early Echocardiography in Acute Heart Failure: Evaluating the Impact of Early Bedside Echocardiography on the Management and Outcomes of Patients with Acute Heart Failure

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ABSTRACT

Background: AHF is a critical event whose diagnosis must be prompt to end up in critical care management. Echocardiography is an essential diagnostic tool since it offers a diagnostic evaluation of cardiac function in patients with AHF minimally invasively. However, the clinical effects of this type of bedside echocardiography performed within the first twelve hours of admission are not well understood.

Objective: The purpose of this study is to assess the impact of performing early bedside echocardiography in patients with AHF at the Hayatabad Medical Complex, Peshawar.

Methods: The present prospective, non-interventional single-center study recruited patients from February 12, 2023 to May 7, 2024 (end of follow-up visit) with AHF hospitalization regardless of cause. A transthoracic echocardiographic examination was done within 12 hours of admission to determine LVEF, valvular lesions, and fluid status. Morgagni's outcomes assessed consisted of death in hospital, number of days actually in the CCU, and overall hospitalization days. Descriptive statistics were done using the SPSS software with an alpha level set at 0.05.

Results: The first echocardiography resulted in treatment modification in 78% of the cases with alterations in diuretic doses (65%), introduction of inotropic agents (34%), and changes in volume administration (40%). The patients who received echocardiography at first instance had a relatively less duration of their stay in CCU: mean 4.2 days compared with the patients who did not receive echocardiography: 6.5 days and overall hospital stay: 7.8 days compared to 8.1 days. Also, the in-hospital mortality was also lower among the patients in the early echocardiography group (7.1 % compared to 15 %, $p < 0.05$).

Conclusion: Here, early goal directed bedside focussed echocardiography is shown to enhance clinician's decision making and individual patient outcome in AHF. These findings are an endorsement of early echocardiography as a routine component of assessment and management of AHF especially in low-resource settings to improve outcome and efficiency.

Keywords: Early Echocardiography, Acute Heart Failure, diagnostic tool

Introduction

Acute heart failure (AHF) is a very fatal condition involving significant healthcare services worldwide. Its admission to hospitals makes it one of the primary causes in elderly people (Ambrosy et al., 2014). Heart failure remains linked with high morbidity and mortality rates and healthcare expenditure, especially in the acute phase of decompensation (Ziaieian & Fonarow, 2016). The heterogeneous etiology, acute patient deterioration, and the need for timely and accurate therapeutic interventions render the management of AHF very challenging. Diagnostic tools that can provide real-time information in regard to cardiac function to help with immediate clinical decisions are a prerequisite in this context. In fact, echocardiography has evolved into an invaluable resource in the diagnosis and management of heart failure.

Echocardiography is a non-invasive imaging modality that will allow the direct visualization of the structure and function of the cardiac system. It is very useful in the understanding of the underlying pathology of heart failure, which includes left ventricular function, the presence of valvular abnormalities, and fluid status—all critical elements in tailoring treatment strategies. Although echocardiography is known to be useful, the time point for such testing in the acute setting, especially in patients who are admitted with AHF, remains nonuniform. A substantial number of research studies remain pertinent regarding the role of early echocardiography, here defined as imaging within a timeframe of hours since admission to the hospital, in the management and treatment outcomes for patients presenting with AHF.

Acute heart failure is defined as a sudden onset or exacerbation of signs and symptoms of heart failure that can precipitate urgent medical attention (Ponikowski et al., 2016). It is often regarded as a heterogamous clinical syndrome in relation to many etiologies that include ischemic heart disease, hypertension, cardiomyopathies, and valvular diseases (McMurray et al., 2012). The clinical presentation of AHF might range from mildly symptomatic dyspnea to severe cardiogenic shock. Basically, the pathophysiology is all about intracardiac pressure at high levels, retention of fluid, and decreased cardiac output—all leading to pulmonary congestion, peripheral edema, and fatigue (Metra & Teerlink, 2017).

Early and accurate diagnosis is therefore inevitable in AHF as it guides therapy and improves the outcome of the patient. The early management of AHF is aimed at stabilization of the hemodynamic status of a patient, often with diuretics, vasodilators, and inotropic agents (Harjola et al., 2017). However, the choice and time of these interventions will depend largely on an accurate judgment of cardiac function, which can only be difficult from clinical signs.

Echocardiography has always been known to be a gold standard in the assessment of heart failure. It gives both structural and functional aspects about the heart. It is therefore inevitable in the primary assessment of heart failure patients given its skill to measure left ventricular ejection fraction, wall motion abnormalities, and valvular function (Lang et al., 2015). In addition, other comorbid conditions like right ventricular dysfunction and pericardial effusion can be identified by echocardiography. These coexist with heart failure and complicate its management.

Echocardiography in AHF has an early assessment that provides critical information bearing an influence on therapeutic decision-making. It may suggest the need to start inotropic support when LVEF is significantly low or to consider mechanical circulatory support in the case of severe mitral regurgitation (Oh et al., 2011). Moreover, echocardiography can guide fluid management by the assessment of inferior vena cava diameter and respiratory variation, which indicate volume status in the patient (Nagueh et al., 2016).

Echocardiography has many established advantages in heart failure. However, the ideal timing of this diagnostic test is unclear, especially in the acute setting. Current guidelines only advise

doing an echocardiography on all patients suspected of suffering from heart failure; however, they make no recommendations on proper timing of test conduct (Ponikowskiet al., 2016). The clinical timing of the echocardiography depends on availability of resources, clinician judgment, and the severity of their condition.

An early bedside echocardiography within a few hours of admission would probably affect decision-making while management before other diagnostic modalities may be out of reach. There has been evidence emerging that in critically ill patients, early echocardiography can be correlated with better diagnoses and management strategy than any other mode of diagnostic modality (Fermann et al., 2019). For example, in patients suspected to have cardiogenic shock, the early echocardiography can help distinguish left ventricular failure from right ventricular failure with potential complications of mechanical myocardial infarction for correct interventions (Vieillard-Baron et al., 2013).

Several studies have investigated the impact of early echocardiography on clinical outcomes in AHF. Early imaging is associated with increased diagnostic accuracy and possibly faster initiation of appropriate therapies with a possible reduction in the length of stay in the hospital, although very limited evidence on its effect on mortality and rates of rehospitalization over the long term exists.

Materials and Methods

It is an observational prospective study conducted from February 12, 2023, to May 7, 2024, at Hayatabad Medical Complex, Peshawar. A total of 430 patients with acute heart failure were included. Patients were considered as such who were 18 years of age or older presenting with clinical symptoms of AHF like dyspnea and peripheral edema, associated with symptoms of fatigue, elevated jugular venous pressure, pulmonary congestion, or decreased cardiac output. Echocardiography was performed on patients within 12 hours of presentation to guide immediate treatments for them. Apart from that, patients excluded in this study included those admitted with chronic heart failure, those who had not been subjected to echocardiography within 12 hours after admission, and those with incomplete clinical data.

This study was conducted in order to assess whether early bedside echocardiography indeed alters the treatment plan and the outcome of patients admitted for acute heart failure. The various echocardiographic parameters, such as left ventricular ejection fraction, valvular abnormalities, and status of the patient, were evaluated. Alterations in treatment involving diuretic titration, initiation/institution of inotropic support, or withdrawal of mechanical ventilation were noted both before and after the performance of echocardiography and were used to evaluate the extent of the influence of echocardiography on clinical treatment decisions.

Data include demographics of the patient, presentation at admission, and findings from echocardiography. The significant endpoints include in-hospital mortality, length of stay in the CCU, and total time in the hospital. Data were analyzed on SPSS. Descriptive statistics were applied to describe the baseline characteristics. Comparators are being done to explore the differential outcome between patient subjects receiving early echocardiography and those whose management decision was solely based on clinical assessment. The study adhered to ethical considerations, and patients or their legal representatives provided informed consent.

Results

A total of patients=430 was admitted with AHF in the emergency ward of Hayatabad Medical Complex Peshawar being enrolled for this study between February 12, 2023, to May 7, 2024. Of these 410 patients 95.3% had bedside echocardiography performed within 12 hours of admission; 20 patients (4.7%) did not have early echocardiography because of operational or clinical concerns. The mean age of the group was 65.4 years +/-12.1 years, where

56 percent were male and 44 percent were female. Ischemic heart disease was the main cause of AHF in our population with 52% followed by hypertension 30% and valvular heart disease 18%.

Table 1 Patient Demographics and Baseline Characteristics

Characteristic	Patients (n=430)
Mean age (years)	65.4
Male (%)	56.0
Female (%)	44.0
Ischemic Heart Disease (%)	52.0
Hypertension (%)	30.0
Valvular Heart Disease (%)	18.0

Impact on Clinical Decision-Making

A clinical observational study showed that early sono-echocardiography at the bedside had a major impact on management. Specifically, in relation to echocardiography, in 78% of the cases changes in the management plan were made. In detail, 65% of patients had to be adjusted regarding their diuretic treatment depending on their fluid balance, and 34% of patients with newly found LVEF $\leq 40\%$ received inotropic medication. Furthermore, valvular disorders were diagnosed by echocardiography in 15 percent of patients that prompted prompt referral to surgery or intervention. Fluid management was also altered for 40% of patients by adjusting IVC diameter and respiratory variability measurements.

Patient Outcomes

In fact, the early echocardiography group revealed enhanced clinical outcomes than patients who were not imaged early. Patients who received an echocardiography early on had a relatively shorter mean days in CCU (4.2 ± 0.3 vs 6.5 ± 0.5 , $p < 0.05$) and number of total, hospitalization days (7.8 ± 0.8 vs 10.1 ± 1.0 , $p < 0.05$). Also, the mortality in the event of within the early echocardiography was significantly lower, 7.1% in contrast with those without early imaging of 15% sensitivity at $p < 0.05$.

Table 2 Patient Outcomes Based on Early Echocardiography

Outcome	Early Echocardiography (n=410)	No Early Echocardiography (n=20)
Mean ICU Stay (days)	4.2	6.5
Mean Hospital Stay (days)	7.8	10.1
In-hospital Mortality (%)	7.1	15.0

Diagnostic Accuracy and Treatment Efficiency

Echocardiography was highly useful in facilitating quicker disposition of the cause of symptoms especially in cardiogenic shocked patients and patients with right ventricular dysfunction. The mean time to the initiation of appropriate therapy was slashed by 30 percent in the early echocardiography group, compared with the patients who received

traditional treatment based on assessment findings. This improved the time of diagnostic of the relevant conditions that warranted use of laid down standard treatment such as ACE inhibitors and beta-blockers in qualifying patients.

The data derived from this study suggest that initial bedside echocardiography has major therapeutic implications and positive impact on AHF.

Discussion

The results of the current study will be important in understanding the patient characteristics of early bedside echocardiography in AHF patients. The study outcomes corroborate the hypotheses that real-time echocardiography performs an important role in the designing of patient care therapy approach, leads to better patient outcome and decreases both, the length of CCU stay and hospitalization. These results support prior research, emphasizing the role of early imaging in the evaluation of patients with acute cardiac conditions (Platz et al., 2017, Price et al., 2015).

One of the main study results in this area was the significance of early echocardiography use in making clinical decisions. In 78% of cases the changes on the echocardiogram resulted in changes of management especially in the diuretics, new inotropic support and fluid management alterations. This is in line with the literature because the echocardiography allows for real-time RV function, volume status, and valve assessment (Lang et al., 2015). For example, identification of LVEF < 40% underwent inotropic therapy in 34% of patients, despite the fact that such an approach has benefits for patients with reduced CO (Harjola et al., 2017). Secondly, an echocardiogram proved to be very valuable in determining the appropriate fluid therapy. Fluid therapy interventions were initiated according to IVC diameter and respiratory variability in 40% of patients. this is especially with a view to the intricate balance of fluids in AHF, where fluid overload has to be strictly managed to avoid such triangulating effects like pulmonary edema as noted by Nagueh et al., (2016). The publication of early echocardiography offered provides real-time data to make changes in the therapeutic treatments immediately, and this might be the reason for better outcomes in the current study.

The single biggest contribution of this study is that early echocardiography is associated with improved patient outcomes. Patients evaluated by early bedside echocardiography conducted, had a shorter length of stay in the CCU of, mean of 4.2 days as compared to a mean of 6.5 days in the patients who did not. Likewise, early echocardiography was associated to a shorter hospital stay of 7.8 days compared with the non-echocardiography group of 10.1 days. Such findings accord with other studies that suggested that early imaging results in prompter accuracy of diagnosis and commencement of adequate treatment, thus avoiding stay in the CCU and the hospital, (Fermann et al., 2019).

Furthermore, utilizing early echocardiography was related with significantly lower in hospital mortality (7,1%) than among patients who did not undergo early imaging (15%). This reduction in mortality is quite commending because the analysis shows that early echocardiography in managing AHF has a life-saving prospect. Because of the phenomenon presented in this study, improved knowledge about its own cardiac function and state of intravascular volume allows more aggressive and individualized treatment, which in turn could have influenced the observed positive changes in survival rates. This evidence corroborates the current literature for the use of early echocardiography in empowering better clinical outcomes in acute cardiovascular conditions, with emergency basis (Vieillard-Baron et al., 2013).

Thus, the findings are in concordance with the available literature and endorse the place of echocardiography in the treatment of acute heart failure. In AHF, Platz et al. (2017) have identified that early echocardiography was useful in decreasing both the in-hospital mortality and the length of stay in the CCU. Likewise, Blecker et al. (2014) found that early

echocardiography enhanced the timing of guideline-recommended medical therapy, ACE, and beta-blocker regimens that are fundamental in management of heart failure. The present study contributes to this line of research by showing the appropriate role of early echocardiography in a resource-limited setting like the Hayatabad Medical Complex in Peshawar.

However, some authors have failed to identify a positive impact of the early echocardiography in heart failure. Certain studies more specifically those done amongst high resource setting have reported lesser enhancement of outcomes possibly attributed to the existence of better equipment's and apparatus that are not much available in low resourced regions (Bloomfield et al., 2013). The present study reaffirms that early imaging is extremely valuable in the management of suspected ALI/ARDS in this resource-limited environment where other more sophisticated diagnostic tests may not be accessible.

The large sample size of 430 patients is one of the useful advantages of this work that gives enough data to evaluate the influence of early echocardiography on AHF prognosis. In addition, the potential design of the study was observational that brought the advantage of making snap observations and therefore avoiding the bias of recall, which is often amplified in case of retrospective studies.

Thus, let me enumerate certain limitations that can be found in the study: First, this was a single-center study carried out at a tertiary care teaching hospital of Peshawar and hence, the result may not be transportable to other tropic settings. Second, the authors failed to consider another important form of the outcome, particularly the readmission rates within a certain time period or long-term survival after the echocardiographic examination. Further, in the study, although, it showed a decrease in both the duration of stay in CCU and in hospital mortality, the efficiency of implementing early echocardiography in the actual clinical practice was not considered. Further research should be devoted to assessing the cost-effectiveness and subsequent benefits of early echocardiography in the treatment of AHF.

Therefore, the findings presented in this research literature have valuable practical implications for future clinical practice, especially in LMICs. Bedside echocardiography using an ultrasound trained physician should be part of the initial assessment of patients in the emergency department with AHF. Understanding the prospects on which critical treatment decisions are based, DOQ can speed up the assessment of acute cardiac function and clarify the patient's fluid situation that may result in better outcomes and decreased healthcare costs. Based on these findings, there is a call to incorporate early echocardiography into the MCI management protocol in absent of other diagnostic tools, for AHF based on the positive result this study has shown.

Conclusion

In this Research, the application of early goal-directed bedside echocardiography in treatment of AHF is analysed comprehensively. The results reveal that early echocardiographic assessment benefits patient care, allowing for optimal and appropriate treatment through early interventions including modification of diuretic dose, initiation of isotropic support, and optimization of fluid management regimes. These improvements threaded down to patient benefits meaning that it decreased CCU length of stay, hospitalization and in-hospital mortality.

The findings are most informative for settings such as the Hayatabad Medical Complex where early diagnostic techniques such as echocardiography, can help in directing the general and more efficient utilization of available resources when other expensive

and performant diagnostic technologies are inaccessible. Based on the findings, implementation of early echocardiography in management of AHF should be incorporated into usual practice especially in resource limited environments.

Further studies should concentrate on longer follow-up results as well as costs of early echocardiography in AHF patients, and echocardiography across a range of different settings. In conclusion, this work provides evidence for applying early echocardiography as defined as a highly useful tool for enhancing prognosis in patients with acute heart failure.

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