Journal of Nursing and Women's Health
Panagiotou C, et al. J Nurs Women's Health 8: 189.
www.doi.org/10.29011/2577-1450.100089
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Research Article

IABP as a Bridge to Decision: A Less Aggressive but Still Effective Approach in Advanced HF Patients with Cardiogenic Shock

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Citation: Panagiotou C, Adamopoulos S, Miliopoulos D, Bonios M, Gkouziouta A, et al. (2023) IABP as a Bridge to Decision: A Less Aggressive But Still Effective Approach In Advanced HF Patients With Cardiogenic Shock. J Nurs Women's Health 8: 189. DOI: https://doi.org/10.29011/2577-1450.100089

Received Date: 04 April, 2023; **Accepted Date:** 10 April, 2023; **Published Date:** 14 April, 2023

Abstract

In this study, we evaluated the effectiveness of Intra-aortic balloon pump (IABP) therapy in improving hemodynamics and peripheral organ function in advanced heart failure (AdHF) patients who were admitted to the Cardiac Intensive Care (CICU) of a tertiary, high-volume, transplant center with impending or established cardiogenic shock.

Hundred-four patients were studied their mean age of was 44 ± 12 years, 76 of them (73.08%) were male. All patients underwent IABP therapy. The median time on IABP support for the entire cohort was 13 days (3 – 41.25). The survival rate was 87.62% (88 patients). We observed our cohort's significant improvement in the hemodynamics after right heart catheterization with a decrease of the right atrium pressure ($p < 0.0001$), PA pressure ($p<0.001$), and pulmonary capillary wedge pressure ($p<0.001$)). There was also a significant decrease in the NT-proBNP levels ($p<0.0001$), and improvement in renal function (e GFR ($p<0.0001$), and urea levels ($p<0.001$). Sixteen patients (15.38%) ended up in CICU on IABP. We found a significant correlation of death with NT-proBNP levels ($p< 0.0014$), renal function ($p< 0.001$), and application of renal dialysis ($p< 0.0001$), intubation ($p<0.006$), and with the value of 24-hour lactic acid ($p<0.0001$).

IABP was an effective initial intervention for AdHF patients experiencing severe clinical deterioration. It was a first-line method of managing patients as a bridge to decision for further therapies with positive clinical response in improving their hemodynamics and peripheral organ function.

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Keywords: Advanced heart failure; cardiogenic shock; cardiac intensive care unit; intra-aortic balloon pump; temporary mechanical circulatory support

Introduction

The Intra-aortic balloon pump (IABP) is a widely used form of temporary mechanical circulatory support (tMCS). The fundamental concept behind the IABP's mechanism of action is counterpulsation which involves inflating the balloon during diastole and deflating it rapidly during systole and remains consistent with that described during its initial experimental use in 1962 by Moulopoulos et al. [1].

IABP is considered the most popular left ventricular assist device and provides support by increasing blood flow to the heart and reducing its workload. The advent of new IABP driving systems, smaller sheaths, and balloon catheters specifically designed for percutaneous insertion has made the use of IABP more convenient and safe [2]. It is commonly used to stabilize hemodynamically compromised patients as a bridge to decision for further therapies and it has become prevalent means of supporting advanced heart failure (AdHF) patients before they receive treatments such as heart transplantation or durable ventricular assist devices (VADs) [3].

Sudden clinical deterioration in AdHF patients is the main reason for repeated hospitalizations, with cardiogenic shock (CS) being the most extreme form of the severe exacerbation of heart failure (HF) symptoms with mortality rates of 30-50% during hospitalization [4–7]. Although the causes and treatments of CS caused by ischemic-related issues have been extensively studied, less is known about CS caused by non-ischemic related issues, even though it has been reported that is one of the primary reasons for admission to cardiac intensive care units [8,9]. Cardiogenic shock caused by heart failure (HF-CS) has now surpassed acute myocardial infarction-related cardiogenic shock (AMI-CS) as the leading cause of cases of CS [9–11].

Regarding its use in patients with CS, IABP is still at the forefront as it has several advantages such as being easy to implant and remove, simple to manage, and cost-effective, although studies have shown mixed results regarding the effect of IABP on mortality and other clinical outcomes, namely improving hemodynamics and maintaining peripheral tissue perfusion, compared to other types of temporary mechanical circulatory support (tMCS) [12]. IABP has been commonly used to support hemodynamics in patients with AMI-CS, however, recent randomized control studies and meta-analyses have not found any survival benefit of IABP use in these settings [13]. In contrast, the efficacy of IABP support in AdHF patients has not been widely studied. There is a lack of research in this area, but small studies have shown that IABP support is effective in patients with both non-ischemic cardiomyopathy and ischemic etiology [14]. Additionally, prolonged IABP support in patients with AdHF has been shown to improve hemodynamics and peripheral organ function [15]. In patients with AdHF-CS the landscape is even murkier as the data are more limited, have not been widely studied, and are largely unspecified, compared to the extensive reports on the use of the intra-aortic pump in patients with AMI-CS [16].

This study describes a high volume single-center experience of using IABP as a first line method of managing AdHF patients as bridge to decision for further therapies. The objectives of our study were to evaluate the hemodynamic and clinical response to IABP in AdHF-CS patients and to investigate if and to what extent it can be an adequate first-line support method in this group of patients. The immediate possibility of escalation to more sophisticated types of tMCS if needed was available.

Methods

Ethical approval

The study has been approved by the Scientific Committee and the Ethics Committee of the Onassis Cardiac Surgery Center which is the only Heart Transplantation Hospital in Greece.

Study population

The study population consisted of AdHF patients. All patients were either on the transplant list or urgently referred for evaluation of advanced therapies. All participants had rapidly developed, or worsening, signs and symptoms of HF with severe clinical deterioration according to INTERMACS profile (Interagency Registry for Mechanically Assisted Circulatory Support) [17], that stratifies AdHF patients based on the severity of their condition and anticipate those who will gain benefit from expedited temporary MCS [16]. All patients were either with impending or with established cardiogenic shock and they were referred to our CICU for urgent placement of tMCS. Clinical evaluation was made by the HF multidisciplinary team and the shock team was available 24/7 to offer the whole range of tMCS if needed in less than 30 min. The exclusion criteria for this study were as follows: deterioration due to ischemia (i.e. diagnosis of AMI during the hospitalization), and absence of pre-implant hemodynamic data.

Data collection

Anonymized clinical data were collected for all study participants. Collected data consisted of demographics, clinical history, and phenotype of HF, co-morbidities, and LVEF. Laboratory data included NT-proBNP, total bilirubin, serum creatinine, urea, and baseline e GFR (MDRD Formula). Lactic acid values were recorded to assess the severity of the shock. Renal and liver function indicators, general blood parameters, and NT-proBNP levels were evaluated before and after IABP insertion. Invasive hemodynamics were measured including catheterization of the pulmonary artery (PA), before and after IABP insertion. The final need to escalate support from IABP to extracorporeal membrane oxygenation (ECMO) and the outcome of the patients concerning the specialized treatments they received, were also recorded.

Outcomes

Patients were considered to have clinical improvement and stabilization on IABP if they were a) weaned from IABP and discharged from the CICU on medical therapy or b) survived to discharge from the CICU and bridged to either transplantation or durable mechanical circulatory support on IABP alone. Patients who did not meet the specified criteria (such as those who passed away or required escalation to another tMCS device during IABP therapy) were classified as having experienced clinical deterioration despite IABP treatment.

Data Analysis

The categorical variables are presented as the absolute number of patients together with the corresponding percentages. Continuous variables are presented as mean ± standard deviation if normally distributed or median values (interquartile range, IQR) otherwise. Normal distribution was checked with Q-Q plots. The continuous variables that had a normal distribution were compared with each other before and after the placement of the IABP with a t-test in pairs, while respectively the continuous variables without a normal distribution were compared with the Wilcoxon test in pairs. A statistically significant difference was considered when $p \leq 0.05$. Univariate analysis followed to correlate the various variables with the final outcome of patients.

Results

Baseline characteristics

Hundred and four (104) patients were studied. Their mean age was 44 ± 12 years, 76 of them (73.08%) were male. Regarding the HF phenotype 84 patients (80.77%) had non-ischemic HF etiology. All patients had a reported left ventricular ejection fraction (LVEF) <40% (20.40 ± 4.94). Emergency referrals from other hospitals of the HF network involved 42.31% of admissions (44 patients), while 57.69% (58 patients) were patients who had completed or were in the process of pre-transplant evaluation for advanced therapies. On admission to the CICU, 83.65% (87 patients) were receiving continuous infusions of three inotropic/vasoconstrictors drugs. The main reasons for admission to the CICU were acute decompensation of heart failure in 58.66% (61 patients), and malignant arrhythmias in 17.3% (18 patients). According to INTERMACS profile, 17 patients (16.35%) were INTERMACS I, 56 patients (53.85%) INTERMACS II, 31 patients (29.8%) INTERMACS III.

All patients received IABP as the first line therapy and the median time on IABP support for the entire cohort was 13 days (3 – 41. 25). The IABP placement was performed within the CICU by the unit's medical staff. Baseline characteristics are summarized in Table 1.

Table 1: Demographics & Clinical Characteristics

Age	years	44.8 ± 12.42
Sex	male, n (%)	76 (73.08%)
Job	n (%)	Unemployed 10 (9.62%), Employed 73 (70.19%), Retired 21 (20.19%)
BMI	kg/m^2	24.28 ± 3.98
Transfers	n (%)	44 (42.31%)
HF phenotype	Ischemic cardiomyopathy, n (%)	20 (19.23%)
	Non-ischemic cardiomyopathy, n (%)	84 patients (80.77%)
INTERMACS stage	n (%)	1 – 17 (16.35%), 2 – 56 (53.85%), 3 – 31 (29.8)
Main reason for admission	The top reason, n (%)	Decompensation 71 (68.27%), Arrhythmias 18 (17.31%), Other 5 (4.81%)
NYHA class	n (%)	IIIb 32 (30.77%), IV 72 (69.23%)
LVEF <40%	n (%) 104 (99,99%)	LVEF: 20.4 ± 4.94

Duration of IABP support	days	13 (3 – 41.25)
Heart rate	bpm	97.92 ± 29.28
Systolic BP	mmHg	83.89 ± 13.86
Diastolic BP	mmHg	45.76 ± 9.49
Total bilirubin	mg/dL	1.40 (0.8 – 3)
Sodium	mEq/L	133.41 ± 5.82
Potassium	mEq/L	4.2 (3.75 – 4.7)
WBC	k/mm3	10149.1 ± 3967.7
CRP	mg/L	26.10 (10 – 51)
Lactate	mmol/l	4.6 ± 2.3
NT-proBNP	pg/mL	9856 (5210.5 – 21345)

Abbreviations: BMI, body mass index; BP, blood pressure; CRP, C-reactive protein; HF, heart failure; IABP, intra-aortic balloon pump; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal pro B-type natriuretic peptide; NYHA, New York Heart Association; WBC, white blood cell

Clinical outcomes (hemodynamics and changes in end-organ perfusion)

Regarding patient outcome, after the IABP hemodynamic support, a significant percentage of patients showed clinical improvement and the biochemical parameters almost normalized. IABP provided clinical stabilization in 72 patients (69.23 %) that completed pre-transplant evaluation and proceeded to surgery with permanent mechanical support or heart transplantation or were weaned from IABP and transferred to the regular ward on medical therapy. In a more detailed description 18 patients (17.31%) were able to be weaned from the IABP support, 11 patients (10.58%) were transplanted, and 42 patients (40.4%) proceeded in durable implantable MCS (VAD therapy). Outcomes are summarized in Table 2.

Table 2: Outcomes

Survival rate	n (%)	88 (87.62%)
Clinical stabilization	n (%)	72 (69.23%)
Weaned from IABP	n (%)	18 (17.31%)
Heart Transplantation	n (%)	11 (10.58%)
VAD therapy	n (%)	42 (40.4%)
Surgery	n (%)	2 (1.92%)
Transfer to other hospitals	n (%)	4 (3.85%)
Therapy escalation ECMO	n (%)	11 (10.57%)
Mortality rate (on IABP)	n (%)	16 (15.38%)

Abbreviations: ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; VAD, ventricular assist device

Significant improvements in patient's hemodynamics were observed with a decrease of the right atrium pressure ($p < 0.0001$), the PA pressure ($p<0.001$), and of the pulmonary capillary wedge pressure ($p<0.001$)). We also noted changes in their laboratory findings. There was a significant decrease in the NT-proBNP levels ($p<0.0001$) and lactate ($p < 0.001$).

There was an improvement in renal function (e GFR (p<0. 0001) and urea levels (p< 0.001)). Changes in hemodynamics and laboratory are summarized in Table 3.

Table 3: Changes in hemodynamics & laboratory

		Pre IABP	Post IABP	p
RA	mmHg	16.91 ± 6.1	12.81 ± 6.66	< 0.0001
RV systolic	mmHg	51.04 ± 15.96	46.98 ± 17.59	< 0.001
RV diastolic	mmHg	14.06 ± 5.21	11.91 ± 7.21	0.01
PA systolic	mmHg	51.07 ± 15.98	46.77 ± 16.66	< 0.001
PA diastolic	mmHg	26.92 ± 9.23	23.20 ± 8.08	< 0.0001
PA mean	mmHg	36.54 ± 11.33	32.86 ± 10.48	< 0.0001
PCW	mmHg	28.39 ± 8.12	24.86 ± 8.62	< 0.001
TPG	mmHg	9.31 ± 5.35	8.11 ± 4.05	0.01
Ao systolic	mmHg	105 ± 12.13	104.5 ± 12.04	ns
Ao diastolic	mmHg	66.32 ± 11.74	65.36 ± 9.45	ns
Ao mean	mmHg	77.56 ± 13.15	79.03 ± 10.38	ns
CO	L/min	2.80 ± 0.84	3.44 ± 0.92	< 0.0001
CI	$L/min/m^2$	1.59 ± 0.64	1.93 ± 0.65	0.05733
PVR	WU	3.72 ± 2.01	2.58 ± 1.34	< 0.0001
SVR	WU	23.59 ± 7.43	20.18 ± 6.03	0.01
CVP	mmHg	16.7 ± 4.75	12.15 ± 3.71	< 0.0001
Laboratory				
	units	Pre IABP	Post IABP	p
NT-proBNP	pg/mL	9856 (5210.5 – 21345)	4656.5 (2258.75 – 7972)	< 0.0001
Urea	mg/dL	80.57 ± 50.82	65.52 ± 48.09	< 0.001
Creatinine	mg/dL	1.70 ± 1.20	1.53 ± 1.29	ns
eGFR (MDRD)	mL/min	54.07 ± 24.71	68.52 ± 36.03	< 0.0001
Lactate	mmol/l	4.6 ± 2.3	3.0 ± 2.3	< 0.001

Abbreviations: Ao, aortic pressure; CI, cardiac index; CO cardiac output; CVP, central venous pressure; eGFR, estimated glomerular filtration rate; NT-proBNP, N-terminal pro B-type natriuretic peptide; PVR, pulmonary vascular resistance; PA, pulmonary artery pressure; RA, right atrial pressure; PCW, pulmonary capillary wedge pressure; RV, right ventricular pressure; SVR, systemic vascular resistance; TPG, transpulmonary pressure gradient

Clinical deterioration and escalation of therapy with additional support with ECMO were needed by 10.57% (11 patients) which was successfully placed by the hospital shock team immediately when required. Sixteen patients (15.38%) ended up in CICU while being on IABP. A statistically significant correlation of death with the value of NT-proBNP ($p < 0.0014$), renal function ($p < 0.001$) and application of renal dialysis ($p < 0.0001$), intubation ($p < 0.006$) as well as the value of 24-hour lactic acid (p <0.001) was observed. Correlation with mortality rate based on univariate analysis is shown in table 4.

Table 4: Correlation with Mortality Rate

Univariate analysis		
	Estimate	p
RA post	0,15 ± 0,08	0.05887
TPG προ IABP	-0.14 ± 0.07	0.0587
NT-proBNP pre	4.707e-05 ± 2.300e-05	0,0407
NT-proBNP post	1.218e-04 ± 3.813e-05	0.0014 *
Urea pre	0.02 ± 0.01	0.00182
Urea post	0.02 ± 0.01	0.000121 *
eGFR pre	-0.04 ± 0.01	0.00415
eGFR post	-0.04 ± 0.01	0.00103 *
Diuresis	2.40 ± 1.27 (< 20 mL/h)	0.0594
Renal replacement therapy 12 (11.54%)	2.55 ± 0.68	< 0.000179 *
Intubation 33 (31.7%)	1.55 ± 0.57	< 0.0066 *
Lactate at 24 h	8.528 (2.767–9.863)	< 0.001*

Abbreviations: eGFR, estimated glomerular filtration rate; NT-proBNP, N-terminal B-type natriuretic peptide; RA, right atrial pressure

Discussion

This study describes a single- high volume heart transplantation center experience of using IABP as a first line intervention of tMCS in AdHF-CS patients as a bridge to decision for further therapies. The escalation to additional alternative therapies is available in the same center when required and covers the whole range of advanced treatment therapies such as heart transplantation and durable MCS.

The main findings of our study are:

1. Clinical stabilization with the use of IABP as a bridge to the decision was achieved in a significant proportion of patients.
2. Escalation of tMCS and placement of ECMO after IABP insertion was finally needed in a relatively smaller proportion of patients than originally referred.
3. An appreciable improvement in hemodynamic parameters and clinical measurements was observed.
4. IABP support had a beneficial effect on NT-proBNP levels and lactate levels as well as renal function in a significant number of patients.
5. Persistent high NT-proBNP levels and 24-hour lactic acid levels, persistent impaired renal function, and application of renal dialysis as well intubation were associated with increased mortality.

The use of IABP in AdHF-CS patients is controversial and debated in the medical community. While IABP has traditionally been utilized as a bridge-to-decision or bridge-to-therapy option for these patients, studies have questioned its efficacy and safety when compared to other mechanical circulatory support devices [13,18]. Overall, the results suggest that IABP can provide sufficient hemodynamic support in this patient population, but its effectiveness varies depending on the underlying cause of CS and other factors related to the individual patient [14,15,18,19]. The majority of previous studies on IABP usage have focused on patients experiencing cardiogenic shock after an acute myocardial infarction (AMI-CS), with limited information available on AdHF patients who experience cardiogenic shock following acute decompensation. As a result, the effectiveness of IABP in this patient group remains the subject of ongoing discussion and many issues are in dispute.

A group of clinical experts has created a set of guidelines for the appropriate use of tMCS devices in patients with cardiovascular disease, especially those with CS (20). These guidelines suggest that tMCS devices, such as the IABP, should be considered as the first line of therapy in patients with CS caused by non-ischemic cardiomyopathy, as a way to bridge to further therapies like advanced heart failure treatments, heart transplantation, or recovery. However, the guidelines emphasize that the use of tMCS devices should be personalized to each patient's clinical situation, hemodynamic profile, and any other health conditions they have. The benefits and risks of using these devices should be carefully evaluated before deciding to use them [20].

Despite advancements in early percutaneous interventions and device technology, CS still has a high short-term mortality rate, ranging from 30% to 50% [16,20]. However, findings from the CardShock study suggest that patients who do not have an acute ischemic cause of CS tend to have a better prognosis. The study's authors suggested that patients with AdHF have a better outcome because they are less likely to have severe underlying coronary artery disease and are more likely to have a reversible cause of their heart failure, such as viral myocarditis or drug-induced cardiotoxicity. They also noted that the treatment approach for AdHF-CS may differ from that of patients with AMI-CS, and indicated the need to determine the optimal therapeutic strategies for this specific group of patients. The study highlighted that patients with AdHF were typically younger and had fewer comorbidities than those with AMI [21]. Our results align with their conclusion that patients with AdHF-CS may have better prognosis and lower mortality rates despite having similar clinical presentation and severity with AMI-CS patients [21].

Our findings suggest that the IABP may be effective in treating AdHF-CS patients. While our data are not randomized, the outcomes of our study are nevertheless promising showing that clinical stabilization can be achieved with the use of IABP. Our study showed clinical stabilization in 69. 23%, a survival rate of 87.62%, and an ICU mortality rate of 15.38%. Our study aligns with previous observations and reports that consider the IABP support an effective strategy as a bridge to decision for advanced therapies as they argue that IABP insertion in patients with decompensated cardiomyopathy allowed for optimization of medical therapy and bridged patients to cardiac transplantation or left ventricular assist device (LVAD) [22].

Cardiogenic shock is a complex condition that presents a spectrum of phenotypes and severity levels [16]. Although AdHF patients may show a more significant response to IABP therapy [23], it is crucial to recognize that the severity of CS varies among individuals and etiologies [16]. The individualization of medical and device-based treatments based on the patient's clinical situation is crucial for improving CS outcomes. Multiple forms of tMCS devices are available to assist patients with AdHF and CS. The selection of a tMCS device may be influenced by various factors, including the patient's medical condition, the extent of cardiogenic shock, and the availability of specialized expertise and equipment. In contrast to other temporary MCS devices, the IABP works by leveraging the patient's inherent pulsatility to achieve the desired results [23]. However, it may not be suitable for severe cases of cardiogenic shock, regardless of the underlying cause. In these scenarios, tMCS devices like percutaneous LVADs or VA-ECMO are more appropriate, as they provide a higher degree of hemodynamic support, including biventricular support for some devices/configurations. However, these devices carry a higher risk of adverse events and should be reserved for situations where full or near-full hemodynamic support is required. The option to escalate therapy should be available, however, as these patients may suddenly experience further clinical deterioration despite initial support [5,21,22,24,25].

The number of patients in our study who required escalation to a more sophisticated device was limited. We consider that the timely placement of the IABP contributed to this encouraging result but more data are needed to draw more accurate conclusions. The right time of intervention is a success criterion in any treatment. Early initiation of treatment enhances the potential expected benefit of the chosen method. In our study, the decision to start IABP support was immediate and the activation of the team started with an imminent deterioration of the patient's condition. Our point of view is reinforced by studies that investigated the impact of early induction of IABP on the prognosis of high-risk patients with acute heart failure (AcHF) and concluded that was associated with a lower incidence of the primary endpoint (35.9% vs. 53.5%, $p<0.026$) and a lower mortality rate (23.1% vs. 44.9%, $p<0.003$) at 1 year compared to those who did not receive early IABP and that it was an independent predictor of improved prognosis at 1 year, overall suggesting that early induction of IABP may have a positive impact on the prognosis of high-risk patients with AcHF [26].

Our study has shown satisfactory hemodynamic response to IABP, which aligns with findings from previous reports that conclude that IABP therapy can be an effective treatment option for patients with chronic HF and CS [23], and specific patient factors can predict the likelihood of stabilization with this therapy [27]. More specifically, there was an improvement in filling pressures, as demonstrated by a decrease in both right atrial pressure and pulmonary capillary wedge pressure, after the IABP insertion. Our findings are in line with those of Rosenbaum et al., whose research demonstrated that AdHF patients who met the criteria for CS and received IABP support as a bridge to transplantation experienced hemodynamic stabilization. The study by Rosenbaum et al. showed significant improvements in all hemodynamic parameters, indicating a positive clinical response to IABP therapy [14]. Additionally as stated by Sintek et al., IABP therapy was associated with improved hemodynamics, including increased cardiac output and decreased pulmonary capillary wedge pressure. In their study higher baseline systolic blood pressure, lower baseline creatinine levels, and shorter duration of cardiogenic shock were predictors of stabilization with IABP therapy [19]. Our assessment aligns with the findings by Fried J et al. According to their study after the IABP insertion, there were enhancements in mean arterial pressure, cardiac output, cardiac index, and pulmonary artery pressures, which resulted in clinical stabilization in 74% of their patients, suggested that temporary mechanical support with an IABP can serve as a bridge to transplantation or as bridge to durable VAD therapy in AdHF-CS patients. They highlighted also that the hemodynamic response to IABP was highly variable but that in selected chronic HF patients with CS, the IABP may be associated with a high probability of clinical stabilization and survival, particularly when used as a bridge to permanent mechanical LVAD support while preserved right ventricular function may predict a favorable response to this therapy [27].

Our findings indicate that utilization of IABP treatment had a positive effect on numerous parameters, including NT-proBNP levels, lactate levels, and renal function. We observed though that patients with persistently high levels of NT-proBNP and 24-hour lactic acid levels as well as impaired renal function were associated with increased mortality rates. The application of renal dialysis and intubation correlated also with a higher mortality rate. In general, our results suggest that the use of IABP therapy can help enhance patient outcomes, but the continued elevation of certain biomarkers may indicate a need for supplementary interventions to improve the prognosis. Based on our research, we have identified several factors that could predict clinical deterioration on IABP and were independently correlated with mortality, notably persistent high NT-proBNP levels, 24-hour lactic acid levels, intubation, persistent impaired renal function, and application of renal dialysis. Similar results were reported in other studies that examined the correlation between elevated NT-proBNP and lactate levels in patients with cardiogenic shock and observed the greater likelihood of mortality in patients with cardiogenic shock if both are elevated [21,28,29]. The study by Valente et al. (2017) showed that lactate was significantly higher in patients with CS and that was independently correlated with increased mortality and highlighted the prognostic significance of elevated lactate in patients with end-stage heart failure and shock compared to those without shock [30]. To summarize, the assessment and prognosis of patients with AdHF-CS necessitate the consideration of both lactate levels and NT-proBNP levels. Elevated levels of these biomarkers have been linked with higher mortality rates in AdHF patients, underscoring the significance of their monitoring in clinical practice. Systematic monitoring provides additional information on the severity of the condition and may help guide treatment decisions [28–32].

While not typically used for this purpose, there is some evidence that IABP therapy may improve diuresis in patients with HF by increasing cardiac output and reducing afterload. AdHF patients are at increased risk of acute kidney injury (AKI), which can lead to further complications and increased mortality. Our study found a significant improvement in renal function with the use of IABP support, which is consistent with other studies. Bezerra et al. concluded that IABP improved organ perfusion and led to decreased serum urea levels after 48 hours of use [33]. Similarly, Estep et al. reported significant improvements in both renal and hepatic function with the insertion of IABP in HF patients [34]. Gjesdal et al. also demonstrated that IABP treatment improved liver and kidney function and allowed for successful heart transplantation [35]. However, the study by Sintek et al. did not find a significant difference in renal function indices, but there was an increase in urine output after the IABP insertion [19].

Givertz MM et al. in their study, aimed to investigate the association between renal function trajectories and clinical outcomes in AcHF patients and revealed that the trajectory of renal function during the first seven days of hospitalization was an independent predictor of adverse outcomes, even after adjusting for baseline renal function and other clinical variables [36]. Based on our findings persistent high urea values and reduced estimated glomerular filtration rate (eGFR) after tMCS was associated with a higher risk of death. Additionally, the use of dialysis increased the mortality risk for our patients.

Our study has shown that intubation was significantly correlated with death. (Estimate: 1.55 ± 0.57, $p < 0.0066$). Mechanical ventilation can be a lifesaving intervention, as it reduces ventricular preload and afterload and, helps manage pulmonary edema by reducing the work of breathing and cardiac output requirements however, HF is considered a risk factor for unsuccessful weaning from the ventilator with a high likelihood of reintubation [37]. According to studies intubation is independently correlated to mortality while weaning from mechanical ventilation requires careful preparation and planning [38]. Regardless of the severity of the underlying disease, failure to wean from mechanical ventilation can further worsen patient outcomes. Failure may occur in 10 to 20% of patients and is associated with a poor outcome, it can lead to prolonged mechanical ventilation and extremely high mortality rates ranging from 25 to 50%. It's also worth noting that around 30% of patients die while still intubated [37,38].

Our study has certain limitations that must be acknowledged. It is a single-center observational study and there is no control group. However, it is worth noting that the sample size is substantial, including one of the largest cohorts of AdHF patients receiving tMCS with IABP in our country. In cases of deterioration, the treatment was immediately escalated to a more advanced support system such as ECMO, based on clinical and objective findings by the shock team. While we evaluated hemodynamic and laboratory parameters before and after IABP insertion, the timing and drug regimens were not uniform in all cases, potentially affecting our ability to draw firm conclusions about the immediate hemodynamic response to IABP and its association with drug treatment. Furthermore, while all patients had measurements of CVP, PA, and CO pressures taken before and after IABP insertion, the clinical response of IABP therapy may have been influenced by other factors not accounted for in our study. Finally, it's important to note that the patient age group was within the allowable limits for pre-transplant screening, and our study only included patients who were candidates for advanced therapies, meaning that older age groups were not included.

Conclusions

IABP is a very effective initial intervention for patients experiencing severe clinical deterioration due to AdHF. The use of IABP has a positive impact on the clinical response of these patients, improving their hemodynamics and peripheral organ perfusion. It is a first line method of managing patients as bridge to decision for further therapies. The importance of early support is being evaluated with favorable outcomes in AdHF-CS patients and in this context, earlier use of IABP may be associated with survival benefit**.** This approach may provide additional time for physicians to make more appropriate decisions, as it appears that the use of IABP confers a favorable impact on the clinical response of these patients providing an opportunity for clinicians to temporarily stabilize their patients.

Disclosures: The authors declare no conflicts of interest related to the content of this manuscript.

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