American Heart Journal Plus: Cardiology Research and Practice 17 (2022) 100145

Contents lists available at ScienceDirect

American Heart Journal Plus: Cardiology Research and Practice

journal homepage: www.sciencedirect.com/journal/american-heart-journal-plus-cardiology-research-and-practice

Research paper

Clinical profile and in-hospital outcome of patients supported by intra-aortic balloon pump in the clinical setting of cardiogenic shock

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ARTICLE INFO

Keywords:
Cardiogenic shock
Acute heart failure
Acute coronary syndrome
Intra-aortic balloon pump
Mechanical support device
Heart transplantation

ABSTRACT

Background: Despite controversial evidences, intra-aortic balloon pump (IABP) is still the most widely used temporary mechanical support device in cardiogenic shock (CS), as a bridge to recovery or to more invasive mechanical supports/heart transplantation.

Methods: We analyzed retrospectively data of all patients receiving IABP for CS from 2009 to 2018 in a referral centre for advanced heart failure and heart transplantation; we included CS following acute coronary syndrome (ACS) and other CS etiologies different from ACS. We excluded patients in which IABP was implanted as a support following cardiac surgery, non-cardiac surgery in patients with severe chronic heart failure, or in elective high risk or complicated Cath Lab procedures.

We focused on in-hospital outcomes (including death, recovery, heart transplantation, LVAD) and IABP complications.

Results: 403 patients received IABP, 303 (75.2%) following ACS and 100 (24.8%) in non-ACS CS. Non-ACS patients were younger (59 ± 18.3 vs 73.1 ± 12.6 years, $p < 0.001$), had lower median left ventricular ejection fraction (LVEF) (25% [18–35] vs 38% [25–45], $p < 0.001$). In patients with non-ACS etiologies IABP was more frequently a bridge to heart transplantation [20% (n = 20) vs 0.3% (n = 1), $P < 0.001$] or LVAD [4% (n = 4) vs 0.6% (n = 2), $P = 0.055$], while ACS patients were more frequently discharged without transplantation/LVAD [65.7% (n = 199) vs 33% (n = 33), $P < 0.001$]. Non-ACS patients showed higher in-hospital mortality [46% (n = 46) vs 33.9% (n = 103), $P = 0.042$]. Post-transplant/LVAD outcome in non-ACS subgroup was favorable (21 out of 24 patients were discharged). Serious IABP-related adverse events occurred in 21 patients (5.2%). Ischemic/hemorrhagic complications, infections and thrombocytopenia were more frequent with longer IABP stay.

Conclusions: Despite therapy including percutaneous circulatory support, mortality in CS is still high. In our experience, in the clinical setting of refractory CS an IABP support represents a relatively safe circulatory support, associated with a low rate of serious complications in complex clinical scenarios.

1. Introduction

Cardiogenic shock (CS) is a complex clinical syndrome in which low cardiac output leads to systemic hypoperfusion, resulting in metabolic and neuro-hormonal changes ultimately causing end-organ dysfunction, and death in 40 to 60% of patients. This clinical scenario may underlie a wide spectrum of etiologies, with acute coronary syndromes (ACS) accounting for the majority of cases [1].

Whereas emergency revascularization has proved to favor long-term survival of patients with ACS complicated by CS [2], most cases of non-ACS CS cannot rely on specific therapeutic strategies to improve outcome, and long-term/permanent mechanical devices or heart transplantation are often required. However, in a prospective observational study, patients with non-ACS CS showed a more favorable outcome while ACS was identified as an independent predictor of in-hospital mortality [1].

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https://doi.org/10.1016/j.ahjo.2022.100145
Received 20 April 2022; Received in revised form 17 May 2022; Accepted 19 May 2022
Available online 27 May 2022

Over the last decades the scientific community has focused on identifying non-pharmacological strategies aiming to increase the survival chances of patients with CS. Intra-aortic balloon pump (IABP) was the first mechanical device developed over 50 years ago by Moulopoulos et al. [3]. The physiological rational of IABP is related to its systolic deflation that reduces afterload and its diastolic inflation which increases diastolic blood pressure and consequently coronary and peripheral organ perfusion. Due to the latter feature, the temporary use of IABP has always been particularly intriguing in cases of CS secondary to ACS; however, available evidence which is restricted to the context of ACS-CS, and is limited by the variability of CS definitions, show no benefit in terms of short and long-term mortality [4–6]. As a result, guidelines on ACS and heart failure management do not recommend the routine IABP use, which may be considered as a short-term mechanical circulatory support in refractory CS as a bridge to recovery, to decision, to bridge, to long term mechanical support or heart transplantation [7–10].

In the clinical setting of CS refractory to drug therapy IABP remains the most commonly adopted temporary mechanical support device [11] due to its relatively simple and rapid insertion, as a bridge to recovery in patients with an acute and reversible cause of CS or as a bridge to heart transplantation or durable left ventricular assist device (LVAD) implantation to achieve pre-operative clinical stabilization. Available data showed that, in refractory CS, IABP treatment was successful in bridging acutely decompensated patients to heart transplantation/LVAD implantation/recovery [12–14].

The aim of our study was to review our experience in using IABP in the clinical setting of CS, including both ACS and non-ACS scenarios, aiming to provide insights of the indications, outcomes and complications, in the context of a referral for advanced heart failure and heart transplantation. In particular, we focused on in-hospital outcomes (including death, recovery, heart transplantation, LVAD), as well as IABP complications and frequency/outcome of patients needing upgrade to venoarterial extracorporeal membrane oxygenation (VA-ECMO) support.

2. Methods

2.1. Study population

We retrospectively included all consecutive patients aged 18 or more receiving IABP support in the clinical setting of CS, hospitalized at the Cardiology Intensive Care Unit (CICU) of our hospital between 2009 and 2018. We included CS following ACS and other CS etiologies different from ACS.

Data collected from medical records included demography, clinical, laboratory and instrumental findings at IABP implant, information on in-hospital management and clinical course. The study was approved by the local ethics committee. We excluded patients in which IABP was implanted as a support following cardiac surgery, non-cardiac surgery in patients with severe chronic heart failure, or in elective high risk or complicated Cath Lab procedures.

2.2. IABP therapy

According to clinical practice of our Institution, we consider IABP implant in patients with cardiogenic shock [7] or unstable pre-shock conditions despite inotropic support, who are expected to have a reversible cause of CS, or could be bridged to heart transplant or long-term mechanical circulatory support (MCS). In the setting of ACS, we consider IABP implant in case of persistent severe hypotension despite successful coronary revascularization.

IABP was inserted via femoral artery in all patients, and the procedure was performed in the Cath Lab. IABP therapy was set at 1:2 mode if spontaneous systolic blood pressure (SBP) $\geq$ 100 mmHg associated with urinary output $\geq$30 ml/h over a 12-h with 1:1 mode was observed, and IABP support was discontinued after the documentation of spontaneous systolic blood pressure (SBP) $\geq$ 100 mmHg associated with urinary output $\geq$30 ml/h over a 12-h weaning period with IABP set at 1:2 mode.

During IABP support all patients received anticoagulation with unfractioned heparin according to aPTT ratio (therapeutic range 1.5–2.5), or low molecular weight heparin 100 U/kg twice daily (with dose reduction in patients with severe renal impairment), or Warfarin with INR range according to clinical indication if the patients was already treated with Warfarin.

2.3. Definitions

ST-elevation-ACS (STE-ACS) and non-ST-elevation-ACS (NSTE-ACS) were diagnosed following standard criteria [8,9].

Major bleedings (including severe or life-threatening bleedings and moderate bleedings but needing red blood cell transfusion) and minor bleedings (including site access minor bleedings) during IABP support were defined according to the Global Use of Strategies to Open Occluded Coronary Arteries (GUSTO) criteria [15].

Thrombocytopenia was defined as a platelet drop >50% with an absolute platelet count less than 100.000/mm^3.

The study endpoints were in-hospital outcomes (including death, recovery, heart transplantation, LVAD), as well as IABP complications and frequency/outcome of patients needing up-grade to venoarterial extracorporeal membrane oxygenation (VA-ECMO) support.

2.4. Statistical analysis

Categorical data were presented as number and percentage; continuous data as mean $\pm$ standard deviation (SD) or median and interquartile ranges for normal and non-normal distribution, respectively. Differences between groups were analyzed with chi-squared test for categorical data and with the non-parametric Kruskal-Wallis test for continuous data. Independent predictors of in-hospital mortality were identified with univariable and multivariable binomial logistic regression analysis. Survival curves were estimated by the Kaplan-Meier method and compared by log-rank test. For all comparisons, P value $<$0.05 was considered statistically significant. All analyses were performed with IBM SPSS Statistics package for Windows, version 25.0 (BM Co., Armonk, NY, USA).

3. Results

3.1. Baseline clinical characteristics

Among the 563 patients supported by IABP at this centre between 2009 and 2018, we excluded 160 receiving IABP treatment following cardiac surgery, non-cardiac surgery in patients with severe chronic heart failure, or elective high risk or complicated Cath Lab procedures. Therefore, our study population consisted in 403 patients (supplementary Fig. 1).

Specific indications for IABP implant are listed in Table 1. ACS complicated by CS accounted for the majority of patients (75.2%, n = 303), mostly represented by ST-segment elevation ACS (STE-ACS) (61.3%, n = 247). Mechanical complications of ACS were present in 30 patients (almost all of them with STE-ACS): ventricular septal rupture in 18 cases, papillary muscle rupture with mitral regurgitation in 8 patients, ventricular free wall rupture in 4 cases.

Non-ACS etiologies were identified in a quarter of cases (n = 100); among these patients CS was the result of decompensation of known chronic heart failure in 76 patients, while it was a first manifestation of heart disease in 24 patients.

Baseline characteristics are shown in Table 2. Overall mean age was approximately 70, with younger patients in the non-ACS subgroup (59 $\pm$ 18.3 vs 73.1 $\pm$ 12.6 years, p $<$ 0.001). As expected, classic

Table 1
Etiologies of cardiogenic shock.

Etiology	n = 403
Acute coronary syndromes	303 (75.2%)
STE-ACS	247 (61.3%)
• LVEF <20%	33 (8.2%)
• Complicated by ventricular septal rupture	18 (4.5%)
• Complicated by papillary muscle rupture with mitral regurgitation	8 (1.9%)
• Complicated by ventricular free wall rupture	3 (0.7%)
NSTE-ACS	56 (13.9%)
• LVEF <20%	9 (2.2%)
• Complicated by ventricular septal rupture	0 (0%)
• Complicated by papillary muscle rupture with mitral regurgitation	0 (0%)
• Complicated by ventricular free wall rupture	1 (0.2%)
Non-acute coronary syndromes	100 (24.8%)
Acute myocarditis	7 (1.7%)
Dilated ischemic cardiomyopathy	27 (6.7%)
Severe aortic stenosis	18 (4.5%)
Severe mitral regurgitation	2 (0.5%)
Idiopathic dilated cardiomyopathy	30 (7.4%)
Hypertrophic cardiomyopathy	2 (0.5%)
Restrictive cardiomyopathy	5 (1.2%)
Arrhythmogenic cardiomyopathy	1 (0.2%)
Endocarditis	1 (0.2%)
Other[a]	7 (1.7%)

LVEF: left ventricular ejection fraction; NSTE-ACS: non-ST-elevation acute coronary syndrome; STE-ACS: ST-elevation acute coronary syndrome.

[a] One patient with hypertensive heart disease and CS precipitated by atrial fibrillation; four patients with acute heart transplant rejection; one patient with CS after resuscitated cardiac arrest in the clinical setting of subdural hemorrhage; one patient with Takotsubo cardiomyopathy.

Table 2
Baseline characteristics of patients with cardiogenic shock supported by IABP overall and in ACS and non-ACS subgroups.

Variables	Overall n = 403	ACS n = 303 (75.2%)	Non-ACS n = 100 (24.8%)	P value
Demographics				
Age, years, mean ± SD	69.6 ± 15.1	73.1 ± 12.6	59 ± 18.3	<0.001
Men, n (%)	268 (66.5%)	209 (68.9%)	59 (59%)	0.087
Risk factors				
Hypertension, n (%)	256 (63.5%)	215 (70.9%)	41 (41%)	<0.001
Hypercholesterolemia, n (%)	177 (43.9%)	146 (48.2%)	31 (31%)	0.003
Diabetes, n (%)	116 (28.8%)	86 (28.4%)	30 (30%)	0.855
Current or previous smoking, n (%)	209 (51.9%)	158 (52.1%)	51 (51%)	0.933
Obesity, n (%)	52 (12.9%)	42 (13.9%)	10 (10%)	0.408
Medical history				
Previous MI, n (%)	107 (26.6%)	75 (24.8%)	32 (32%)	0.196
Previous PCI, n (%)	80 (19.9%)	57 (18.8%)	23 (23%)	0.443
Previous CABG, n (%)	21 (5.2%)	17 (5.6%)	4 (4%)	0.712
Previous stroke/TIA, n (%)	36 (8.9%)	25 (8.3%)	11 (11%)	0.526
Previous PAD, n (%)	45 (11.2%)	39 (12.9%)	6 (6%)	0.087

cardiovascular risk factors such as hypertension and hypercholesterolemia were more frequent in the ACS subgroup.

In the majority of patients hospitalized for ACS (85%, n = 258), IABP support was started at admission during emergency revascularization procedure, while in the non-ACS subgroup IABP support was started after a mean of 7.8 ± 14.6 days from hospital admission.

Clinical characteristics at IABP implant are listed in Table 3. Patients with ACS were more frequently resuscitated from cardiac arrest [29.4% (n = 89) vs 11% (n = 11), p < 0.001]. Clinical and instrumental findings in non-ACS group showed an overall worse functional status compared to ACS patients: higher heart rate, lower hemoglobin and platelet count, higher creatinine and lower sodium values, higher bilirubin and ALT values, higher values of CRP, reflecting the context of a pre-existent chronic condition in most of these patients. Moreover, in non-ACS group, lower median left ventricular ejection fraction (LVEF) along with signs of pulmonary congestion were often detected.

3.2. In-hospital management and clinical course

Management and procedures are presented in Table 3. In the ACS subgroup, coronary angiography was performed in all patients and coronary revascularization in 92% (n = 279), mostly with PCI (90.4%, n = 274). Therapeutic management of non-ACS subjects usually included administration of inotropic agents [80% (n = 80) vs 33.8% among ACS (n = 102), p < 0.001], in particular dopamine and dobutamine.

Patients with non-ACS etiologies required a longer IABP stay and a more frequent device repositioning; nevertheless, a worsening of clinical condition among these cases was often observed and 23 subjects (23%) received further mechanical circulatory support with VA-ECMO compared to only four patients (4%) with ACS (p < 0.001). Lastly, non-ACS cases more often needed renal replacement therapy compared to the ACS group [13% (n = 13) vs 5.3% (n = 16), p < 0.001]. Average length of hospital stay was 10 days for ACS patients and 42 days for non-ACS patients.

3.3. In-hospital outcome

As shown in Table 4, overall in-hospital mortality was 36.9% (n = 149), higher among non-ACS patients [46% (n = 46) vs 33.9% (n = 103), p = 0.042]. For non-ACS patients, IABP more frequently represented a bridge to heart transplantation [20% (n = 20) vs 0.3% (n = 1), p < 0.001] or LVAD [4% (n = 4) vs 0.6% (n = 2), p = 0.055]. Post-transplant/LVAD outcome in non-ACS subgroup was favorable (21 out of 24 patients were discharged). Notably, 35 patients with non-ACS etiologies were considered eligible for heart transplantation (20 were already on the heart transplant waiting list at the time of hospitalization, 15 were screened during hospital stay), of whom 21 (20 in non-ACS subgroup vs 1 patient with ACS) were actually “bridged” to transplant (Fig. 1). Out of the 14 not transplanted eligible patients, 8 died (4 due to sepsis - 2 of them during concomitant VA-ECMO support -, 2 due to multiorgan failure, 1 of intracranial hemorrhage during concomitant VA-ECMO support, and 1 of ischemic stroke during concomitant ECMO support), 1 patient was successfully implanted with LVAD, and 5 patients were discharged.

Non-ACS patients tended to have a higher in-hospital mortality without transplantation/LVAD [43% (n = 43) vs 33.3% (n = 101), p = 0.092], while ACS patients were more frequently discharged without transplantation/LVAD [65.7% (n = 199) vs 33% (n = 33), p < 0.001].

Within the non-ACS stratum, a similar outcome was observed between de novo acute heart failure - 24 patients - and acutely decompensated chronic heart failure - 76 patients (supplementary Fig. 2).

Independent predictors of short-term mortality in the overall population were older age [OR 1.46 (95% CI 1.19–1.78), p < 0.001], altered mental status at IABP implant [OR 2.24 (95% CI 1.33–3.78), p = 0.002], higher serum glucose levels [OR 1.03 (95% CI 1.00–1.05), p = 0.027], need for renal replacement therapy [OR 4.57 (95% CI 1.65–12.64), p = 0.003], inotropic agents use [OR 5.33 (95% CI 3.07–9.25), p < 0.001] and upgrade to VA-ECMO support [OR 3.47 (95% CI 1.17–10.25), p = 0.024]. Higher hemoglobin levels resulted to be protective [OR 0.82 (95% CI 0.74–0.92), p = 0.001] (Table 5).

In our series, 27 patients were supported with VA-ECMO (4 ACS

Table 3
Clinical presentation at IABP implant and in-hospital treatment of patients with cardiogenic shock supported by IABP overall and in ACS and non-ACS subgroups.

Variables	Overall n = 403	ACS n = 303 (75.2%)	Non-ACS n = 100 (24.8%)	P value
Presenting characteristics at IABP implant				
Systolic blood pressure, median (Q1-Q3)	77 (63–85)	76 (61–83)	80 (69–90)	0.030
Heart rate, bpm, median (Q1-Q3)	85 (70–100)	84 (70–98)	95 (75–110)	0.002
Lactates, mmol/l, mean ± SD	3.5 (1.4–7.4) (180/403)	3.5 (1.6–8.6) (116/303)	3.5 (1.3–6.5) (64/100)	0.247
Altered mental status, n (%)	163 (40.4%)	119 (39.3%)	44 (44%)	0.413
Pulmonary congestion, n (%)	254 (63%)	181 (59.7%)	73 (73%)	0.011
Intubation, n (%)	130 (32.3%)	102 (33.7%)	28 (28%)	0.325
Sinus rhythm, n (%)	283 (70.2%)	214 (70.6%)	69 (69%)	0.157
Atrial fibrillation, n (%)	72 (17.9%)	49 (16.2%)	23 (23%)	
Other rhythm, n (%)	48 (11.9%)	40 (13.2%)	8 (8%)	
Resuscitated from cardiac arrest/appropriate IDC therapy, n (%)	100 (24.8%)	89 (29.4%)	11 (11%)	<0.001
Laboratory and instrumental findings				
White blood cells, $\times 10^3$/mmc, median (Q1-Q3)	12.1 (9.3–15.8) (390/403)	12.3 (9.4–15.8) (290/303)	11.8 (8.8–15.5) (100/100)	0.156
Hb, g/dl, mean ± SD	12.2 ± 2.3 (390/403)	12.5 ± 2.3 (290/303)	11.3 ± 2.3 (100/100)	<0.001
Platelets, $\times 10^3$/mmc, median (Q1-Q3)	227.5 (174–293) (390/403)	234 (183–294) (290/303)	205.5 (148–293) (100/100)	0.023
Glucose, mg/dl, median (Q1-Q3)	145 (111–209) (386/403)	155 (123–230) (303/303)	119 (88–166) (83/100)	<0.001
Creatinine, mg/dl, median (Q1-Q3)	1.4 (1.1–2) (389/403)	1.3 (1–1.9) (289/303)	1.6 (1.2–2.2) (100/100)	0.001
Sodium, mmol/l, median (Q1-Q3)	140 (137–143) (392/403)	141 (138–144) (292/303)	137 (132–142) (100/100)	<0.001
Potassium, mmol/l, median (Q1-Q3)	4.3 (3.9–4.8) (390/403)	4.3 (3.9–4.8) (290/303)	4.2 (3.7–4.7) (100/100)	0.056
Total bilirubin, mg/dl, median (Q1-Q3)	0.7 (0.5–1.1) (381/403)	0.6 (0.4–0.9) (283/303)	1.3 (0.6–3.1) (98/100)	<0.001
AST, U/l, median (Q1-Q3)	74 (36–222) (374/403)	76 (37–211) (278/303)	51 (32–251) (96/100)	0.682
ALT, U/l, median (Q1-Q3)	39 (21–88) (378/403)	37 (22–72) (281/303)	45 (20–276) (97/100)	0.017
CRP, mg/dl, median (Q1-Q3)	2.2 (0.6–7.3) (346/403)	1.8 (0.5–7.6) (252/303)	3.8 (1.16–6.8) (94/100)	0.039
LVEF (%) at baseline, median (Q1-Q3)	35 (25–45) (387/403)	38 (25–45) (290/303)	25 (18–35) (97/100)	<0.001
In-hospital management and clinical course				
Duration of IABP support, days, median (Q1-Q3)	2 (1–6)	2 (1–4)	6 (2–18)	<0.001
IABP repositioning, n (%)	34 (8.4%)	20 (6.6%)	14 (14%)	0.036
Inotropic agents, n (%)	182 (45.3%)	102 (33.8%)	80 (80%)	<0.001
VA-ECMO, n (%)	27 (6.7%)	4 (1.3%)	23 (23%)	<0.001
Renal replacement therapy, n (%)	29 (7.2%)	16 (5.3%)	13 (13%)	<0.001
RBCs transfusion, n (%)	85 (21.1%)	40 (13.2%)	45 (45%)	<0.001
ICU length of stay, days, median (Q1-Q3)	8 (4–15)	7 (3–13)	12 (6–32)	<0.001

ACS: acute coronary syndrome; ALT: alanine aminotransferase; AST: aspartate aminotransferase; CABG: coronary artery bypass graft; CRP: C-reactive protein; Hb: hemoglobin; IABP: intra-aortic balloon pump; ICD: implantable cardioverter-defibrillators; ICU: intensive care unit; LVEF: left ventricular ejection fraction; PCI: percutaneous coronary intervention; RBCs: red blood cells; SD: standard deviation; VA-ECMO: venoarterial extracorporeal membrane oxygenation.

Table 4
In-hospital outcome of patients with cardiogenic shock supported by IABP overall and in ACS and non-ACS subgroups.

Variables	Overall n = 403	ACS n = 303 (75.2%)	Non-ACS n = 100 (24.8%)	P value
In-hospital outcome				
Overall in-hospital mortality	149 (36.9%)	103 (33.9%)	46 (46%)	0.042
IABP bridge to heart transplantation	21 (5.2%)	1 (0.3%)	20 (20%)	<0.001
IABP bridge to LVAD	6 (1.5%)	2 (0.6%)	4 (4%)	0.055
In-hospital mortality without transplantation/LVAD	144 (35.7%)	101 (33.3%)	43 (43%)	0.092
Discharged without transplantation/LVAD	232 (57.6%)	199 (65.7%)	33 (33%)	<0.001
Complications during IABP support				
Peripheral/visceral ischemia	12 (2.9%)	8 (2.6%)	4 (4%)	0.344
Ischemic stroke	1 (0.2%)	0 (0%)	1 (1%)	NA
Hemorrhagic stroke	1 (0.2%)	0 (0%)	1 (1%)	NA
Major bleeding	9 (2.2%)	7 (2.3%)	2 (2%)	0.606
Minor bleeding	38 (9.4%)	28 (9.2%)	10 (10%)	0.478
Infection	29 (7.2%)	19 (6.2%)	10 (10%)	0.152
Thrombocytopenia	32 (7.9%)	12 (3.9%)	20 (20%)	<0.001
Site access vascular complication	4 (0.9%)	3 (0.9%)	1 (1%)	0.682

ACS: acute coronary syndrome; IABP: intra-aortic balloon pump; LVAD: left ventricular assist device; NA: not applicable.

patients and 23 non-ACS patients) (Fig. 1). Among them 11 non-ACS patients were "bridged" with VA-ECMO to heart transplantation and two of them died, one of haemorrhagic shock due to mediastinal bleeding far after the end of ECMO support and another one due to cardiogenic shock with multiorgan failure despite ECMO support after heart transplantation. No ACS patients were bridged to heart transplantation with VA-ECMO.

Sixteen patients were not "bridged" to heart transplantation/LVAD implant: between them 11 non-ACS patients died while on VA-ECMO and 1 non-ACS patient experienced recovery, while among ACS patients 3 died while on VA-ECMO and 1 died after LVAD implantation (in this case central VA-ECMO support was started immediately after LVAD implantation for hemodynamical instability).

Independent predictors of short-term mortality in both ACS and non-ACS subgroups are described in supplementary Tables 1 and 2, respectively.

Severe complications during IABP support were relatively rare (Table 4) and did not result to directly impact prognosis according to multivariable analysis. In particular, peripheral/visceral ischemia was observed in 2.9% (n = 12) and major bleedings in 2.2% (n = 9), without differences between ACS and non-ACS groups. One ischemic stroke and one hemorrhagic stroke occurred during concomitant ECMO support, both among non-ACS patients. Minor bleedings occurred in 9.4% (n = 38), infections in 7.2% (n = 29), and site access vascular complications (which included arterial dissections and pseudoaneurysms) in 0.9% (n = 4), with no differences between groups. Thrombocytopenia was observed in 7.9% (n = 32), more frequently in non-ACS patients

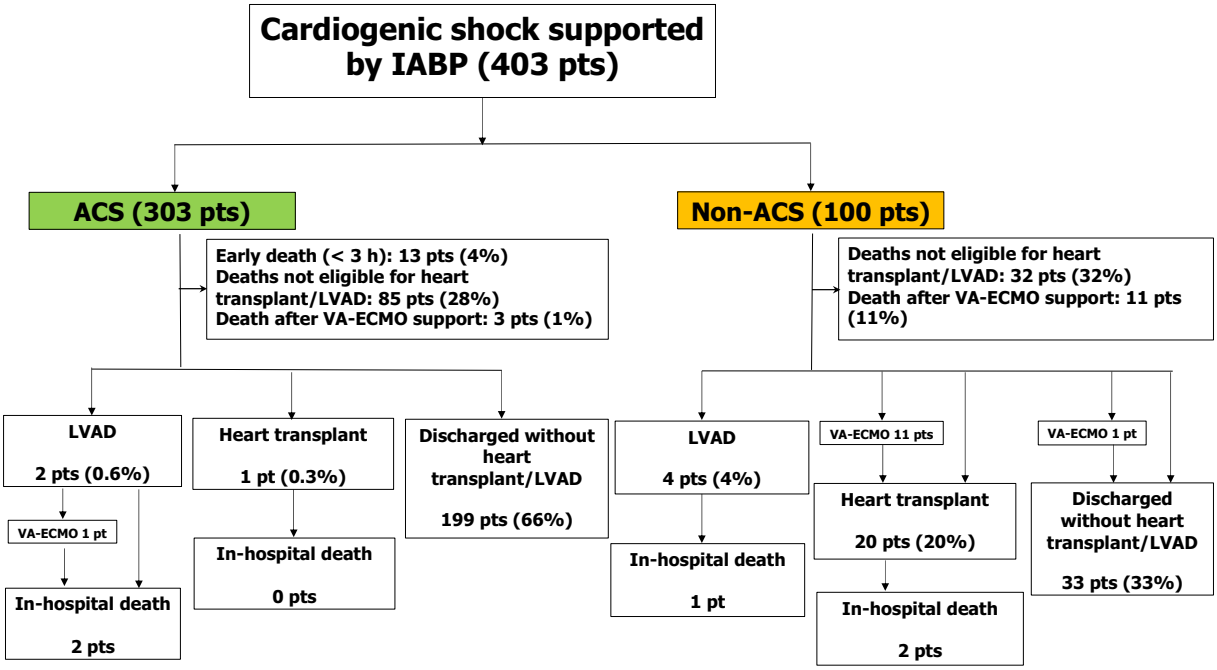

Fig. 1. Study population and in-hospital outcomes

Table 5
Risk factors for short-term mortality of patients with cardiogenic shock supported by IABP overall.

Variable	Multivariable analysis	
	OR (95% CI)	P value
Age, for each 10 years increase	1.46 (1.19–1.78)	<0.001
Altered mental status	2.24 (1.33–3.78)	0.002
Hb, for each g/dl increase	0.82 (0.74–0.92)	0.001
Glucose, for each 10 mg/dl increase	1.03 (1.00–1.05)	0.027
Renal replacement therapy	4.57 (1.65–12.64)	0.003
Inotropic agents	5.33 (3.07–9.25)	<0.001
VA-ECMO	3.47 (1.17–10.25)	0.024

AUC (Area under the ROC Curve) = 0.83.
IABP: intra-aortic balloon pump; VA-ECMO: venoarterial extracorporeal membrane oxygenation.

compared to ACS [20% (n = 20) vs 3.9% (n = 12), p < 0.001], probably due to prolonged IABP support. Moreover, among patients with a IABP support >10 days (n = 52) compared to subjects supported up to 48 h (n = 208), a significant increased risk of ischemic complications (ischemic stroke/peripheral ischemia/visceral ischemia) [13.5% vs 1.4%, p < 0.001], hemorrhagic stroke/major bleeding (7.6% vs 2.4%, p = 0.021), minor bleedings (19.2% vs 9.6%, p = 0.016), infections (15.4% vs 2.4%, p < 0.001), and thrombocytopenia (34.6% vs 0%, p < 0.001) was observed (supplementary Table 3). No statistically significant time related differences were found with respect to the rate of site access vascular complication.

4. Discussion

This study provides a detailed analysis of clinical characteristics and short-term outcome of patients supported by IABP for CS. The most significant findings are:

- CS supported with IABP is confirmed as a marker of poor prognosis, being associated with a 36.9% of in-hospital mortality;
- patients with ACS were older but with a possibly reversible cause of CS, justifying a shorter IABP support. These results suggest a possible "overuse" of IABP in patients undergoing urgent myocardial revascularization;
- in the context of non-ACS etiologies, most of patients had pre-existing chronic heart failure and thus presented more often with renal and liver dysfunction, showing a worse outcome compared to ACS patients, despite a younger age;
- the rate of serious complications occurred during IABP support was low, especially in case of a short IABP stay, and did not impact prognosis.

While there is no evidence in favor of routine IABP use in CS complicating ACS, its use in non-ACS CS, especially in patients evaluated for LVAD or heart transplantation candidacy, has been poorly investigated. A monocentric retrospective study comparing 1-year outcome of 32 patients receiving orthotopic heart transplantation after IABP support with 135 electively transplanted patients found that IABP does not affect long-term outcome, with few IABP related complications (0.05 complications per patient-week of support) [12].

Similarly, in another small retrospective study of 50 patients with end-stage heart failure supported by IABP through the left axillary-subclavian artery, a successful rate of heart transplantation was observed with a 90-day post-transplant survival reaching 90% [12]. The median duration of support was 18 days, and 4 patients presented significant thromboembolic or bleeding events.

In the ALTSHOCK multicenter clinical trial [14] acute decompensated heart failure patients presenting with CS were managed with low-dose epinephrine and promptly short-term mechanical circulatory support (16 out of 24 patients were transitioned to IABP and 1 to IABP and VA-ECMO) leading to satisfactory outcomes. In fact, 21 patients (87.5%) survived at 60 days (primary outcome); among them, 13 (61.9%) underwent LVAD implantation, 2 (9.5%) underwent heart transplantation, and 6 (28.6%) improved on medical treatment.

In our series, patients with non-ACS etiologies receiving LVAD (4 patients, 4%) or heart transplantation (20 patients, 20%) showed a favorable short-term outcome. Specifically, in-hospital mortality was observed in 1 out of 4 patients treated with LVAD and in 2 out of 20 transplanted patients.

Available data on VA-ECMO used as a direct bridge to heart transplantation indicates that, due to the frequent device related

complications (mainly ischemic and haemorrhagic) and the extreme clinical condition in which it is generally used, post-transplant survival of such patients remains inferior than cases assisted by any other circulatory support device, including IABP [16–18].

Our series confirmed the higher mortality of patients supported with VA-ECMO both among patients "bridged" to transplantation (2 over 11) and among patients not "bridged" to transplantation (15 over 16) (Fig. 1).

In fact, need for VA-ECMO resulted to be an independent predictor of short-term mortality in our overall population, along with older age, altered mental status at IABP implant, higher serum glucose levels, need for renal replacement therapy, use of inotropic agents, and lower hemoglobin levels. Differently from previous evidence [1], ACS was not associated with a worse prognosis and, on the contrary, the majority of ACS patients were discharged without heart transplantation/LVAD. Notably, the lower mortality rate observed among our ACS cohort can be explained by the inclusion of ACS subjects with acute severe hypotension despite coronary revascularization, without the possibility of confirming the diagnosis of CS with other criteria.

5. Conclusions

Despite maximal therapy including mechanical circulatory supports, the mortality of patients with CS is still high. In our experience, in the clinical setting of refractory CS an IABP support represents a relatively safe circulatory support in complex clinical scenarios, associated with a low rate of serious complications, mainly occurring in cases of a prolonged device stay. Future studies are needed to investigate the real added benefit of more advanced and more invasive mechanical support strategies compared to IABP.

Study limitations

Due to the monocentric nature of our work, the size of the study population is limited. Moreover, our data were collected retrospectively.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ahjo.2022.100145.

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