REVIEW ARTICLE

Analysis of the Latest Clinical Trials of Mechanical Circulatory Support in Cardiogenic Shock and their Potential Role in Modifying Practice Guidelines

Análisis de los últimos ensayos clínicos de soporte circulatorio mecánico en el shock cardiogénico y su potencial rol en modificar las guías de práctica

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ABSTRACT

Cardiogenic shock can complicate the course of ST-segment elevation myocardial infarction in approximately 10% of cases and is associated with high mortality. In this context, practice guidelines recommend the use of mechanical circulatory support devices based on expert opinion or non-randomized studies. Between 2023 and 2024, three randomized clinical trials using ECMO or Impella have been published. The results of these trials and their potential impact on practice guidelines are discussed in the present review.

Key words: Shock, Cardiogenic - Myocardial Infarction - Practice Guideline - Circulatory Support

RESUMEN

El shock cardiogénico puede complicar la evolución del infarto agudo de miocardio con elevación del segmento ST en aproximadamente el 10 % de los casos, y se asocia a elevada mortalidad. Las guías de práctica recomiendan en este contexto el empleo de dispositivos de soporte circulatorio mecánico con base en opinión de expertos o estudios no aleatorizados. Entre 2023 y 2024 se han publicado 3 ensayos clínicos aleatorizados con el empleo de ECMO o Impella, cuyos resultados y posible influencia en las guías de práctica se discuten en la presente revisión.

Palabras claves: Shock cardiogénico - Infarto agudo de miocardio - Guía de práctica clínica - Soporte circulatorio

INTRODUCTION

Cardiogenic shock can occur in approximately 10% of patients with ST-segment elevation myocardial infarction (STEMI) with mortality rates ranging between 40% and 50%. (1) Current clinical practice guidelines recommend the use of short-term mechanical circulatory support devices in patients with cardiogenic shock (recommendation class IIa, with a level of evidence C of the European guidelines, or B-NR of the American guidelines, that is, based on expert opinion or non-randomized studies). (2,3) Yet, after the negative results of the IABP-Shock II trial with intra-aortic balloon pump in infarct-related cardiogenic shock, the use of these devices has increased in recent years, particularly with the advancement in extracorporeal membrane oxygenation (ECMO) implantation techniques. (4,5) Three randomized clinical trials that emerged in 2023 and 2024 are among the most relevant on the use of short-term mechanical circulatory support devices in cardiogenic shock published so far and will likely impact on the indications and the level of evidence in practice guidelines: the ECMO-CS trial, ECLS-Shock trial and the recently published DanGer-Shock trial.

These studies analyze the use of ECMO and Impella in cardiogenic shock, predominantly in the set-

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ting of MI. Briefly, ECMO is a type of mechanical circulatory support that drains blood from the venous system and returns oxygenated blood into the arterial circulation. It can provide complete circulatory and ventilatory support in patients with left ventricular, right ventricular or biventricular heart failure. The Impella device is a catheter-mounted microaxial pump inserted percutaneously that drains blood from the left ventricle and expels it into the ascending aorta, unloading the left ventricle. It is essential to ensure that blood oxygenation is adequate and that right ventricular function is not significantly impaired to guarantee adequate left ventricular filling. This review will address the main aspects of each study and any potential changes in clinical practice that may result from their analysis.

ECMO-CS TRIAL

This multicenter, unblinded, randomized clinical conducted only in the Czech Republic aimed to compare immediate implementation of ECMO versus an initially conservative therapy (allowing downstream use of ECMO) in patients with rapidly deteriorating or severe cardiogenic shock. The primary endpoint was the composite of death from any cause, resuscitated cardiac arrest, and implementation of another mechanical circulatory support device at 30 days. Other secondary endpoints such as death from any cause at 30 days and safety criteria were also evaluated. (6)

Patients with any type of rapidly deteriorating severe cardiogenic shock of the Society for Cardiovascular Angiography and Interventions (SCAI) shock classification stage D-E were included. (7) This implies hemodynamic instability necessitating administration of pressor agents to maintain a mean arterial pressure >50 mm Hg and impaired left ventricle systolic function; or hemodynamic impairment (decreased cardiac index or systolic blood pressure with requirement of norepinephrine and dobutamine) and metabolic impairment (lactate greater than 3 mmol/L or central venous saturation less than 50% in two consecutive values, with no tendency to improve). Hypovolemia (central venous pressure <7 mm Hg or pulmonary capillary wedge pressure <12 mm Hg) should be excluded. In the initial conservative treatment group, downstream use of ECMO was possible in case of further worsening of the hemodynamic status, defined as rise of serum lactate by 3 mmol/L in comparison with the lowest value during the past 24 hours. Patients with shock due to pulmonary embolism or cardiac tamponade, hypertrophic cardiomyopathy, and those with potential contraindications for the use of ECMO (severe peripheral arterial disease precluding arterial cannula insertion, severe bleeding, moderate or severe aortic regurgitation or aortic dissection, among others) were excluded.

From September 2014 to January 2022, 58 patients were included in the initial ECMO group and 59 patients in the conservative group. This indicates that recruitment was relatively slow, likely due to the fact that it was conducted at four centers within a single country. It should be noted that the study population comprised patients with a median age of 66 years [interquartile range, (IQR) 56-70], which is older than the typical age range for this type of mechanical circulatory support in our setting and in much of the world. Most patients were men (73.5%). The primary cause of cardiogenic shock was MI (65% of cases, STEMI, NSTEMI or due to mechanical complications), and 23.1% were due to decompensation of chronic heart failure. Approximately 11 % of the patients had presented cardiac arrest. Median lactate level was 5 mmol/L (IQR 3.2-8.0) and median vasoactive-inotropic score, a measure of the amount of pharmacologic cardiovascular support, was 61 (IQR 30-124); both parameters were relatively high.

There were no significant differences in the primary composite endpoint or in death from any cause at 30 days or resuscitated cardiac arrest. In the early conservative group, 39% of patients required downstream use of ECMO support, with no differences in the endpoints in the intention-to-treat or per protocol analysis. In terms of safety outcomes, the supplementary data showed a non-significant increase in the number of bleeding events in the per protocol analysis (30.9% vs. 13.9%, p = 0.067).

In addition to the aforementioned limitations of the study, another factor to consider is that the sample size was calculated based on a 50% reduction in the primary endpoint. This difference may be excessive and increase the likelihood of a type II error, i.e., a "false negative" result in a relatively small sample. Furthermore, the study was designed to find a difference in the composite primary endpoint, and thus the results of the secondary endpoints should be considered hypothesis-generating. Additionally, the sample size was not sufficient to conduct subgroup analyses.

What key takeaways can we draw from this first clinical trial? It could be argued that the patients were already receiving high doses of pressor agents or inotropic drugs at the time of randomization. This raises the question of what might have happened if an even earlier ECMO strategy had been implemented with lower doses of vasoactive agents. But it is true that the protocol did not require high doses, and that the inclusion criteria permitted the incorporation of patients at substantially lower doses. This may be indicative that they were in fact stage D and E patients according to the SCAI shock classification, for whom pharmacological support had to be rapidly escalated. Furthermore, the protocol allowed for the use of ECMO in the conservative group when the patient did not stabilize rapidly, which occurred in 39% of cases. This suggests that an initial pharmacological treatment plan may be a viable strategy, even in critically ill patients. Yet, it is essential to maintain close monitoring to ensure downstream use of an ECMO strategy if necessary. This approach could prevent the potential

complications associated with the unrestricted use of these devices, which were higher in this study, though they did not reach statistical significance probably due to the relatively small sample size.

ECLS-SHOCK TRIAL

The ECLS-Shock was a multicenter, unblinded, randomized clinical trial conducted in Europe (Germany and Slovenia) which evaluated if the routine early use of ECMO in patients with infarct-related cardiogenic shock reduces death from any cause at 30 days compared to usual treatment. (8) Secondary endpoints included the need for new revascularization, renal replacement therapy, length of intensive care unit stay, time until hemodynamic stabilization or duration of pressor agent therapy and safety endpoints (peripheral ischemic vascular complications, bleeding, stroke or systemic embolism).

The trial included patients with infarct-related cardiogenic shock, defined as hypotension (systolic blood pressure < 90 mm Hg for more than 30 minutes, or requirement of pressor agents to maintain a systolic pressure > 90 mm Hg) with elevated lactate level (> 3mmol/L) and signs of impaired organ perfusion (altered mental status, cold limbs, or urine output < 30 ml/h), that is, cardiogenic shock stage C or higher of the SCAI classification. Patients with shock due to mechanical complications of AMI, cardiac arrest > 45 minutes, severe peripheral arterial disease arterial precluding arterial cannula insertion, shock lasting > 12 hours, or patients > 80 years were excluded. Of the 877 patients screened between June 2019 and November 2022, 417 were included in the final analysis, representing the largest number of patients included in a study of this kind in this clinical setting to date.

The study was well designed. ECMO was initiated during the index coronary angiography (preferably before revascularization). The use of an antegrade arterial femoral sheath was strongly recommended to reduce the risk of lower limb ischemia. Unlike the ECMO-CS trial, details regarding ECMO management in the intensive care unit and predefined criteria for left ventricular unloading and weaning were provided.

Mean age was 63 years (IQR 56-70) and 81.3% were men. Two thirds of the patients presented with STEMI and the left anterior descending artery was the most common culprit vessel (47.6%), while two thirds of the patients had multivessel disease. Although emergency myocardial revascularization surgery was considered, primary coronary intervention was the most common revascularization strategy (96.6% of cases).

As previously mentioned, the study was designed to include critically ill patients, truly in cardiogenic shock, because such patients were thought to be the most likely to benefit from mechanical circulatory support. However, the resulting population was more severely ill than anticipated: 77.7% of patients had experienced cardiac arrest prior to randomization, 86.3% required invasive mechanical ventilation, 95.4% had altered mental status, and the median lactate level was 6.9 mmol/L. Consequently, 48.4% of the patients were in SCAI shock stage D or E and 30-day mortality was 48.4%, higher than the one reported in other studies. (4,9)

Regarding the study results, there were no differences in death from any cause at 30 days in the group treated with early ECMO strategy compared to the control group: 47.8% vs. 4.9%, relative risk (RR) 0.98 (95% CI 0.80-1.19, p = 0.81). In addition, secondary endpoints were similar in both groups. There were also no differences in any of the established subgroups. However, there were significant differences in the safety outcomes. The ECMO group exhibited a higher incidence of moderate or severe bleeding (23.4% vs. 9.6%; RR 2.44, 95% CI 1.50-3.95) and vascular ischemic complications (11% vs. 3.8%; RR 2.86, 95% CI 1.31-6.25).

Some limitations of the study include the lack of blinding, which is difficult to implement in this type of intervention, and the inclusion of centers with both medium and high volumes of ECMO to enhance external validity. This resulted in the participation of many centers that included few patients, and their limited experience could have influenced the results. However, the post hoc analysis did not demonstrate an effect of patient volume in the results. Although 12.5% of patients in the control group crossed over to the ECMO group, there were no differences in the intention-to-treat analysis compared to the per-protocol analysis. However, it is noteworthy that 15.8% of patients in the control group received other type of mechanical circulatory support, mainly the Impella device, which may have attenuated the differences between the groups. Finally, the increase in afterload produced by the use of ECMO in this context can be deleterious, and although criteria for left ventricular unloading were established in the study, it was only used in 5.8% of the patients.

In order to understand the interpretation and impact on current practice of this study, it is essential to contextualize the results and analyze the pathogenesis of infarct-related cardiogenic shock. Given the severity of illness in the ECLS-Shock trial population, it is unlikely that any current treatment, including early ECMO, will have a significant impact compared to the standard treatment: early revascularization. The supplementary material shows that the initial elevated lactate levels return to normal levels and glomerular filtration rate improve in both groups within the first 24-36 hours. Additionally, time until hemodynamic stabilization was relatively short (median 3.1 days) compared to other etiologies of cardiogenic shock, Consequently, the ECMO group required support for a median of 2.7 days. The potential benefit of the circulatory support provided by ECMO may have been partially offset by its higher rate of complications and increased afterload. This calls for a reconsideration of

the current approach to these patients in some situations. In fact, in the publication, presentation at the European Congress of Cardiology 2023 and in several interviews, the authors point out that the routine use of ECMO in this patient population should be reconsidered.

INDIVIDUAL PATIENT DATA META-ANALYSIS OF ECMO IN PATIENTS WITH INFARCT-RELATED CARDIOGENIC SHOCK

After the publication of ECMO-CS trial and ECLS-Shock trial, the two largest randomized clinical trials on the use of ECMO in this context, Zeymer et al. performed an individual patient data meta-analysis including both trials and two smaller studies. (10) Only patients with infarct-related cardiogenic shock were included, (n = 567). Median age was 64 years (IQR 57-71), 81% were men, and 68% were STEMI patients. At the time of randomization, patients presented with a median pH of 7.21 (IQR 7.09-7.31), lactate level of 6.5 mmol/L (IQR 4.1-9.9), and creatinine level of 1.3 mg/dL (IQR 1.1-1.6). Table 1 summarizes the main results of the meta-analysis. The primary outcome was death from any cause at 30 days.

There were no differences in death from any cause at 30 days, but there was a higher rate of associated complications such as moderate to severe bleeding or peripheral ischemic vascular complications. Therefore, this meta-analysis concludes that the early unrestricted use of ECMO in infarct-related cardiogenic shock does not increase survival. Further analysis is required to determine whether mechanical circulatory support with devices that reduce left ventricular afterload can be beneficial. This is partially answered by the DanGer-Shock trial.

DANGER-SHOCK TRIAL

The DanGer-Shock study was a multicenter, unblinded randomized clinical trial conducted in Europe (United Kingdom, Germany and Denmark) which compared routine use of the Impella CP device inpatients with MI-related cardiogenic shock with standard care. (11) The primary endpoint was death from any cause at 180 days. This is an uncommon outcome in contemporary cardiology, as numerous clinical trials are based on composite endpoints that may lack a clear physiological correlation between their components. In addition, analysis strategies such as win-ratio are usually used so that the trials can be considered with a positive outcome. The secondary endpoint included a composite of escalation of treatment to additional mechanical circulatory support, heart transplantation, or death from any cause and number of days alive out of hospital. Additionally, safety endpoints were analyzed and included ischemic vascular complications, bleeding, stroke, and need for renal replacement therapy, among others.

Unlike the ECLS-Shock trial and the ECMO-CS trial, which included STEMI and NSTEMI patients, the DanGer-Shock trial only included patients with STEMI-related cardiogenic shock, defined as hypotension (systolic blood pressure < 100 mm Hg or requiring pressor agents), tissue hypoperfusion (lactate greater than or equal to 2.5 mmol/L) and left ventricular ejection fraction < 45%. Patients with significant right ventricular failure (because, unlike ECMO, the Impella device can assist only one ventricle), with shock due to MI mechanical complications or who remained with altered mental status after out-of-hospital cardiac arrest were excluded. Patients were randomized to Impella vs. standard care before or up to 12 hours after revascularization, depending on when cardiogenic shock was diagnosed. Escalation to mechanical circulatory support was allowed in the control group but not to Impella CP to avoid significant crossover (which was only 1.7%). Like the ECLS-Shock trial, details regarding Impella management in the intensive care unit and predefined criteria for escalation to other mechanical circulatory support devices were provided.

Between January 2013 and July 2023, 179 patients were included in the Impella group and 176 patients in the standard care group. The trial was initially intended to include only centers in Denmark, but because of slow enrollment it was expanded in 2019 to include patients in Germany and in 2021 in the United Kingdom. Thus, most patients were randomized from 2019. The study population had a median age of 67 years and 79.2 % were men. SCAI cardiogenic shock stage C was observed in 55.5 % of the patients and the median lactate level was 4.5 mmol/L (IQR 3.3-

Table 1. Results of the meta-analysis by Zeymer et al. (10)

	ECMO (n=284)	Control (n=283)	Odds Ratio (CI 95%)
Primary outcome			
Death from any cause at 30 days	46 %	48 %	0.93 (0.66–1.29)
Secondary outcomes			
Moderate to severe bleeding at 30 days (BARC 3-5)	25 %	12 %	2.44 (1.55–3.84)
Stroke at 30 days	4 %	3 %	1.41 (0.56–3.57)
Peripheral ischemic vascular complications at 30 days.	11 %	4 %	3.53 (1.70–7.34)

BARC: British Academic Research Consortium; ECMO: extracorporeal membrane oxygenation

7.1). After excluding patients resuscitated from cardiac arrest who remained with a Glasgow Coma Scale < 8, only 20.3 % had presented this event, versus 77. 7 % in the ECMO-CS trial and 11 % in the ECLS-Shock trial. Interestingly, the time from symptom onset to randomization to Impella and control groups was 4.8 hours (IQR 2.4-12.8) and 3.8 hours (IQR 2.2-9.4), respectively, and the time from randomization to placement of the Impella device was 14 minutes (IQR 8-29). Therefore, most patients in the Impella group received mechanical circulatory support within the initial five-hour period following symptom onset.

Regarding outcomes, death from any cause was 45.8% in the Impella group and 58.5% in the standard care group [hazard ratio (HR) 0.74; 95% CI 0.55-0.99; p = 0.04], with an absolute risk reduction of 12.7% and a number needed to treat to prevent one death of only 8. The supplementary material shows that most of the deaths were due to cardiac causes and occurred in within the first 30 days. The subgroup analysis shows the benefit was lower in patients with higher initial systolic blood pressure, something that the authors point out may be due to the fact that these devices are less efficient with high afterload. Additionally, there was a tendency to greater benefit in patients below the median age of 67 years, which is consistent with our context of mechanical circulatory support and with that of other countries. This is evidenced by the recently published Impella registry of the Cardiogenic Shock Working Group, where the average age was 58.6 years. (12) The secondary endpoint also favored the Impella group (52.5% vs. 63.6%; HR 0.72; 95% CI 0.55-0.95). However, the use of these devices was also associated with higher incidence of adverse events, with the composite safety endpoint (major bleeding, limb ischemia, hemolysis, device failure or worsening aortic regurgitation) occurring in 24% of patients in the Impella group and 6.2% in the standard care group (HR 4.74; 95% CI 2.36-9.55). This implies a number needed to harm of 5 patients, reflecting the high complication rate of these devices even in high-volume centers. The Impella group had higher incidence of moderate or severe bleeding (21.8 % vs. 11.9 %; HR 2.06, 95% CI 1.15- 3.66), limb ischemia (5.6 % vs. 1.1 %; HR 5.15, 95% CI 1.11-23.84), renal replacement therapy (41.9 % vs. 26.7 %; HR 1.98, 95% CI 1.27 - 3.09) and sepsis with positive blood culture (11.7 % vs. 4.5 %; HR 2.79, 95% CI 1.20- 6.48)

In addition to the previously mentioned limitations, the study protocol was so meticulous in the management and selection of patients that of the 1211 screened patients, only 355 were randomized. This partially limits the external validity of the study and requires that we interpret the significant reduction in mortality in this study with caution, as it may not be applicable to all cardiogenic shock scenarios. Furthermore, it is important to mention that in the secondary per protocol analysis and not in the intention-to-treat analysis (but without adjusting for multiplicity and excluding patients who received Impella in the control group and those who did not receive it in the Impella group) the benefit in survival was borderline (HR 0.77; 95% CI 0.57 -1.03), perhaps in part because of the smaller number of patients.

These results raise questions about the impact of the DanGer-Shock trial. Few studies that have demonstrated a positive impact on survival in cases of infarct-related cardiogenic shock: the Shock-trial in 1999 with early revascularization, (13) the CULPRIT-SHOCK trial with initial revascularization of the culprit vessel only (14) and now the DanGer-Shock trial with the use of Impella. Only the DanGer-Shock reduced the primary endpoint of death from any cause.

While it is true that there were more adverse events in the Impella group, they do not appear to be significant enough to overshadow the benefit of a 26% reduction in mortality with these devices. It is important to note that the primary endpoint was death from any cause, not just cardiovascular mortality. Patients who were assigned to treatment, despite experiencing more complications, had a greater survival, which is finally the most relevant outcome in the medical treatment approach. In any case, we should bear in mind that in centers with less experience with the Impella device or in a daily scenario outside the rigor of a clinical trial, the increase in the rate of complications could potentially offset the benefit, mainly if associated with other devices. (15)

SUMMARIZING THE EVIDENCE

The ECMO-CS trial, the ECLS-Shock trial, and their meta-analysis represent the most significant studies in the field of ECMO and cardiogenic shock in recent times. The third study, EURO-Shock, was expected to address similar issues but was unfortunately suspended before recruitment was completed due to the COVID-19 pandemic. The study included only 35 patients and did not provide conclusive data. However, it could be included in the aforementioned meta-analysis. (16) These studies demonstrated no benefit in 30-day survival with the early use of ECMO in infarct-related cardiogenic shock and a higher rate of complications when compared to standard care. This does not indicate that ECMO should no longer be used. It is important to note that 39% of patients in the control group of the ECMO-CS trial required subsequent ECMO support (which was a planned aspect of the trial, designed to compare early use of ECMO versus a conservative approach, with the latter allowing for the use of ECMO if necessary). In the ECLS-Shock trial, 12.5% of patients in the control group also required this device, and if we add that 15.8% of the control group required another mechanical circulatory support device, mainly Impella, we see that in both studies approximately 1 out of 3 patients allocated to medical treatment ultimately required the use of ECMO or another device. In other words, there is still a role for ECMO even in infarct-related cardiogenic shock.

However, when viewed from another angle, early use of ECMO was associated with a higher rate of complications without improving survival rates even in critical cases, and 2 out of 3 patients who received medical treatment did not require ECMO. In summary, the evidence does not support the implementation of an early, unrestricted use strategy across all patients. It is possible to initially stabilize patients with pharmacological support, prioritizing early revascularization and, if there is no response, mechanical circulatory support can be considered.

ECMO should not be considered a treatment but a bridge to another strategy and a circulatory support. In parallel, the focus should always be on solving the etiology that led to cardiogenic shock. Myocardial infarction is not an exception, and early revascularization of the culprit vessel is the standard care for cardiogenic shock. Therefore, the use of ECMO support does not provide any actual additional benefit and increases the incidence of complications.

In contrast to the unfavorable outcomes observed in ECMO trials, the DanGer-Shock trial has explored the potential advantages of Impella in cardiogenic shock secondary to STEMI, demonstrating a 26% reduction in death from any cause at 180 days. Unlike the use of ECMO, which increases the afterload, Impella results in left ventricular unloading by driving antegrade blood flow from the ventricle into the aorta. Some small studies or studies in animal models have suggested that this mechanism may have benefits in limiting the extent of infarct size by increasing coronary perfusion, decreasing myocardial oxygen uptake, and activating protective signaling pathways. (17-19) In addition, large registries conducted in Europe and the United States comparing ECMO with Impella in this setting demonstrated a clear advantage for Impella, with lower complication rates and lower in-hospital mortality. (20) Further analysis is required to determine the success of ongoing studies, including REVERSE (NCT03431467), ANCHOR (NCT04184635), and UNLOAD (NCT05577195). These studies will assess the efficacy of an ECMO strategy with left ventricular unloading using Impella or intra-aortic balloon pump and my provide insights into the potential role of these devices in different scenarios.

It is important to consider that Impella has also been associated with complications, so it should not be used unrestrictedly. Indeed, some registries, such as the Cardiogenic Shock Working Group, have demonstrated that the rate of complications increases significantly when associated with the use of other mechanical circulatory support devices. In this context, the benefit seems to be lost, and the use of devices may even be harmful. (12,21) It should be noted that in this registry Impella devices 5.0 and 5.5 were used, which provide higher flow rates than Impella CP. In addition, they provide full circulatory support and not just partial support and do not constitute a ventricular unloading strategy in association with another device. This raises the question if in this population, the use of Impella should be preferred over ECMO and, if used in combination initially, early weaning from ECMO to continue support with high-flow Impella alone may be a viable option.

CONCLUSIONS

These studies require us to reconsider the use of mechanical circulatory support devices in a clinical scenario such as that of infarct-related cardiogenic shock, where mortality remains high. Revascularization of the culprit vessel should be the priority, and it seems reasonable to adopt an initial strategy of pharmacological support, and to resort to ECMO in refractory and selected cases to reduce complications. In the context of STEMI, early use of Impella would contribute to reduce mortality. In addition, in cases where biventricular support is required or if there is concomitant ventilatory failure, ECMO remains the device of choice.

How could these studies modify the guidelines? Probably in the case of infarct-related cardiogenic shock, the early and routine use of ECMO is not recommended (Class III, Level of evidence B, or Class III, Level of evidence B-R according to the guidelines considered). In STEMI-related cardiogenic the use of Impella, if available, should be considered (Class IIa Level of evidence B or Class IIa Level of evidence B-R).

Finally, central expertise and appropriate patient selection to minimize complications and maximize benefits, and thorough treatment of the underlying etiology from the outset remain the cornerstones to ensure successful use of any mechanical circulatory support device.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web).

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