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ARTICLE TITLE	PERIOPERATIVE ANESTHETIC MANAGEMENT IN PATIENTS WITH HEART FAILURE: FROM RISK ASSESSMENT TO HEMODYNAMIC OPTIMIZATION, INTEGRATING FUNCTIONAL CAPACITY ASSESSMENT AND EXERCISE PREHABILITATION – A NARRATIVE REVIEW
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PERIOPERATIVE ANESTHETIC MANAGEMENT IN PATIENTS WITH HEART FAILURE: FROM RISK ASSESSMENT TO HEMODYNAMIC OPTIMIZATION, INTEGRATING FUNCTIONAL CAPACITY ASSESSMENT AND EXERCISE PREHABILITATION – A NARRATIVE REVIEW

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ABSTRACT

Background: Heart failure (HF) increases perioperative complications and mortality in patients undergoing non-cardiac surgery. Both heart failure with reduced ejection fraction and preserved ejection fraction increase cardiovascular risk and require perioperative management.

Aim: This review summarizes evidence on perioperative anesthetic management in patients with HF undergoing non-cardiac surgery, focusing on risk assessment, medical therapy optimization, intraoperative hemodynamic management, fluid therapy, postoperative monitoring and impact of exercise on recovery.

Materials and Methods: This narrative review included PubMed-indexed studies published between 2021 and 2026. ESC consensus statements, randomized trials, and large cohort studies were analyzed to summarize practical recommendations for perioperative management of HF.

Results: Preoperative evaluation should include clinical assessment, natriuretic peptide measurement, and echocardiography. Optimization of medical therapy and euvolemia is essential. During surgery, maintaining MAP \geq 65 mmHg, careful fluid therapy, and early vasopressor use may reduce myocardial injury.

Conclusions: Perioperative management of patients with heart failure should include risk assessment, prehabilitation, hemodynamic control, multidisciplinary care, and functional capacity evaluation to improve short-term outcomes.

KEYWORDS

HF, HFrEF, HFpEF, Perioperative Care, Hemodynamic Monitoring, Quality of Care

CITATION

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1. Introduction

Heart failure (HF) remains one of the strongest risk factors of perioperative morbidity and mortality in patients undergoing non-cardiac surgery [2, 9]. As the number of older surgical patients increases and cardiovascular survival improves, many of the patients with heart failure demand unique clinical approach. Both HFrEF and HFpEF are associated with elevated perioperative risk. While HFrEF is defined by impaired systolic function and limited contractile reserve, HFpEF is characterized by diastolic dysfunction, ventricular stiffness, and heightened sensitivity to preload and heart rate changes [1, 16]. These differences directly influence anesthetic management and intraoperative hemodynamic strategy.

Recent evidence highlights the prognostic value of natriuretic peptides and the clinical relevance of myocardial injury after non-cardiac surgery (MINS) [4, 14]. These findings highlight the need for structured, personalized perioperative management.

From a functional perspective, heart failure represents a state of reduced exercise tolerance and cardiopulmonary reserve. Parameters derived from cardiopulmonary exercise testing, such as peak VO₂ and ventilatory efficiency (VE/VCO₂ slope), may be associated with long-term prognosis and may show how vulnerable a patient is during the perioperative period. Structured exercise training has been demonstrated to improve these parameters and enhance quality of life across HF phenotypes [20]. Adding the functional capacity assessment into perioperative stratification may help guide anesthetic management with functional outcomes and quality of care.

The aim of this review is to summarize contemporary evidence on perioperative anesthetic management in patients with heart failure undergoing non-cardiac surgery, focusing on risk stratification, prehabilitation, optimization of therapy, intraoperative hemodynamic targets, and postoperative surveillance.

2. Materials and Methods

This narrative review was based on a structured search of PubMed/MEDLINE for peer-reviewed studies published between 2024 and 2026. Search terms included “heart failure,” “perioperative,” “non-cardiac surgery,” and “hemodynamic monitoring.” ESC consensus statements, randomized trials, and large cohort studies were prioritized. Studies were selected according to methodological quality and clinical relevance.

3. Pathophysiological Background

Heart failure includes a range of structural and functional abnormalities that impair the heart’s ability to respond appropriately to physiological stress. The perioperative period is characterised by anaesthesia-induced vasodilation, inflammatory activation, fluid shifts and sympathetic fluctuations. These factors place substantial demands on the haemodynamics of patients with HF, which may exceed their limited adaptive reserve.

3.1 Systolic Dysfunction

In HFrEF, reduced ventricular contractility restricts the ability to increase stroke volume in response to surgical stress. Impaired Frank–Starling mechanics and decreased beta-adrenergic responsiveness reduce the ability to compensate for sudden changes in preload and afterload. Anaesthetic-induced vasodilation can lead to a rapid decrease in systemic vascular resistance. When combined with myocardial depression, this can result in hypotension and low cardiac output states. Therefore, these patients are particularly vulnerable to excessive anaesthetic depth, rapid preload shifts and increases in afterload that elevate myocardial oxygen demand without improving forward flow.

3.2 Diastolic Dysfunction

In comparison, HFpEF is characterized by impaired ventricular relaxation and increased myocardial stiffness. Although ejection fraction is preserved, ventricular filling is highly dependent on proper diastolic time, atrial contribution, and controlled preload. Tachycardia shortens diastole and decreases ventricular filling time, while even small fluid overload may elevate filling pressures and lead to pulmonary congestion [1, 16]. Consequently, HFpEF patients may present significant hemodynamic instability despite apparently normal systolic function. Potential rapid changes in heart rate and fluid therapy during the perioperative period may increase risk in this heart failure phenotype.

3.3 Right Ventricular Involvement

Right ventricular dysfunction often occurs in advanced HF and increases perioperative risk by itself. The right ventricle is particularly sensitive to acute increases in pulmonary vascular resistance. Hypoxia, hypercapnia, acidosis, and elevated intrathoracic pressures during mechanical ventilation may all increase right ventricular afterload, potentially leading to acute right-sided failure. Right ventricular involvement should be recognized to guide ventilatory and hemodynamic strategies.

4. Preoperative Risk Stratification

Accurate risk stratification is essential for the perioperative management of patients with heart failure (HF). As well as traditional surgical risk scores, an evaluation should include clinical status, biomarkers and imaging findings in order to provide a more accurate estimate of cardiovascular risk.

4.1 Clinical Assessment

Clinical evaluation remains fundamental. Functional capacity, symptom severity and recent episodes of decompensation are all strong predictors of adverse outcomes during the perioperative period. Recent hospitalisation for heart failure has been associated with a significantly higher perioperative mortality rate [9]. A careful assessment of New York Heart Association (NYHA) class, exercise tolerance and the presence of arrhythmias or congestion enables the identification of patients for whom elective procedures should be postponed until stabilisation is achieved.

4.2 Natriuretic Peptides

The measurement of natriuretic peptides has emerged as a valuable tool in clinical assessment. Elevated NT-proBNP concentrations before surgery independently predict cardiac events and short-term mortality after adjustment for established risk scores [4]. Biomarker-guided stratification can provide objective insight into subclinical myocardial stress, potentially justifying more intensive monitoring during surgery and aftercare for selected patients.

4.3 Imaging and Risk Models

Echocardiography provides a characterisation of the structure and function of the ventricles, including systolic function, diastolic parameters and pulmonary pressures. Importantly, preserved ejection fraction does not exclude clinically relevant risk, which is a key consideration in the assessment of patients with heart failure. Although current predictive models and machine learning-based algorithms help to estimate short-term mortality [11, 12], such tools should support rather than replace individualised clinical judgement, particularly in complex heart failure (HF) phenotypes.

5. Preoperative Optimization

Continuation of guideline-directed medical therapy is fundamental in stable patients. Mineralocorticoid receptor antagonists reduce mortality and hospitalization in HFrEF and should be maintained when clinically possible [19]. ESC consensus recommendations highlight individualized optimization, particularly in patients with borderline blood pressure or advanced ventricular dysfunction [15].

Volume status should be carefully assessed prior to surgery, as both hypovolemia and congestion increase perioperative risk. Elective procedures should be postponed in patients with active decompensation, uncontrolled arrhythmias, or cardiogenic instability.

Following adequate preoperative optimization, intraoperative management becomes the most important modifiable determinant of outcome.

6. Choice of Anesthetic Technique

The selection of anaesthetic techniques should reflect the underlying ventricular physiology and the anticipated surgical stress. As no single approach has been shown to be superior for all patients with heart failure, management must be tailored to the individual.

In HFrEF, a limited contractile reserve increases the risk of anaesthetic-induced myocardial depression and sudden reductions in preload. Therefore, careful titration of induction agents and avoidance of excessive anaesthetic depth are critical. The balance between reducing afterload and maintaining coronary perfusion must be considered in the context of baseline ventricular function.

In HFpEF, poor ventricular relaxation means that cardiac output is highly dependent on sufficient filling and a well-controlled heart rate. Tachycardia, loss of atrial contribution or sudden preload reduction may provoke disproportionate haemodynamic instability despite a preserved ejection fraction [1, 16]. The maintenance of sinus rhythm and the avoidance of significant sympathetic fluctuations are essential principles. Although regional anaesthesia can reduce surgical stress and afterload, extensive neuraxial blockade may cause sudden sympathetic withdrawal and hypotension, which can be poorly tolerated by patients with limited cardiovascular reserve [5]. Consequently, the anaesthetic technique should be considered within the context of a broader haemodynamic plan.

7. Hemodynamic Monitoring

Effective perioperative management of HF depends on precise hemodynamic assessment. Traditional reliance on intermittent blood pressure measurement may be insufficient in patients with impaired cardiovascular reserve.

7.1 Perfusion Pressure and Hypotension

Prolonged intraoperative hypotension has been consistently associated with myocardial injury and adverse postoperative outcomes [14]. Observational data suggest that a mean arterial pressure (MAP) below 65 mmHg is linked to an increased risk of myocardial injury and necrosis (MINS); however, patients with chronic hypertension or advanced ventricular dysfunction may require higher, more individualised perfusion targets. 'Relative hypotension', defined as a decrease from a patient's usual blood pressure, is gaining attention as a clinically important phenomenon, but it is still not well studied in heart failure (HF) patients.

7.2 Cardiac Output and Advanced Monitoring

In cases of moderate-to-severe heart failure (HF), arterial pressure alone may not reflect adequate tissue perfusion. Reduced stroke volume can occur alongside preserved systemic vascular resistance, which can mask low cardiac output states. Advanced haemodynamic monitoring, including pulse contour analysis (PCA) or minimally invasive cardiac output devices, can offer further insight during high-risk procedures [3]. However, there is still limited strong evidence showing that routine use of these technologies improves outcomes in HF patients.

7.3 Echocardiographic Assessment

Intraoperative echocardiography provides a real-time evaluation of ventricular filling, contractility and right ventricular performance. Parameters such as global longitudinal strain have been suggested as reliable indicators of myocardial dysfunction and predictors of negative outcomes [7, 13]. While promising, the integration of strain-based metrics into standardised perioperative protocols requires further validation.

Haemodynamic monitoring in heart failure (HF) patients should be personalised, taking into account the invasiveness of the procedure, the patient's heart health, and their surgical risk.

8. Fluid and Vasoactive Strategy

Fluid and vasoactive management should be directly informed by hemodynamic monitoring findings, particularly in patients with limited cardiac reserve.

In heart failure, fluid therapy should be used carefully to control preload rather than simply replacing lost volume. In HFrEF, administering excessive fluid can increase filling pressures without enhancing cardiac output once the Frank–Starling mechanism is impaired. Furthermore, inadequate preload can reduce cardiac output and organ perfusion. Therefore, small fluid doses with frequent reassessment are more appropriate than aggressive fluid therapy.

In HFpEF, increased ventricular stiffness makes patients more susceptible to fluid overload. Therefore, careful and limited fluid therapy is often recommended, especially during procedures involving low blood loss. The aim is to maintain a normal fluid balance rather than increasing the circulating volume.

Vasoactive agents play a central role in maintaining perfusion pressure. Norepinephrine is generally preferred for treating intraoperative hypotension due to its balanced effect on systemic vascular resistance and coronary perfusion. The early use of vasopressors may reduce the need for fluid boluses. In cases of low cardiac output, inotropic support such as dobutamine may be considered, although this must be balanced against the risk of tachyarrhythmia and increased myocardial oxygen consumption.

Levosimendan has been evaluated in randomised trials in the perioperative setting, but current data do not support its routine use to prevent complications in non-cardiac operations [17].

9. Postoperative Management

The postoperative period is a time of increased haemodynamic vulnerability for patients with heart failure. Surgical stress, inflammation, fluid shifts and the lingering effects of anaesthesia can lead to delayed cardiovascular instability when acting together. Notably, myocardial injury following non-cardiac surgery (MINS) often occurs within the first 48–72 hours and frequently goes unnoticed clinically [9, 14].

Therefore, structured postoperative monitoring is essential, particularly for high-risk patients. Regular troponin measurements can facilitate the early detection of heart injury, even in patients with no obvious ischemic symptoms. Haemodynamic monitoring, either continuous or intermittent, should be adapted to baseline ventricular function and the intraoperative course. Fluid status should be regularly reassessed because fluid therapy during surgery may not accurately reflect intravascular volume post-operatively. Both fluid overload and excessive diuresis can worsen the condition of patients with limited cardiac reserve. In HFpEF, attention should be paid to signs of pulmonary congestion, whereas reduced cardiac output may be more common in HFrEF.

Once haemodynamic stability is achieved, guideline-directed medical therapy should be restarted and optimised. Close cooperation between anaesthesia, cardiology and surgical teams enables the early detection of clinical deterioration and the appropriate adjustment of treatment.

The postoperative period should therefore be considered a continuation of perioperative care, as patients with heart failure remain vulnerable to cardiovascular complications during this phase.

10. Functional capacity assessment and exercise prehabilitation.

Functional capacity is a key factor in determining perioperative risk in patients with heart failure (HF), as it reflects the combined performance of the cardiovascular, pulmonary and skeletal muscle systems. Reduced cardiopulmonary reserve restricts the body's ability to cope with the physiological stress of surgery, leading to an increased risk of complications and mortality after surgery. Consequently, assessing functional capacity has become an important part of modern perioperative risk assessment.

The most common method of objectively evaluating exercise tolerance is cardiopulmonary exercise testing (CPET), which remains the gold standard for assessing global cardiopulmonary reserve. CPET enables the measurement of peak oxygen uptake (VO_2 peak), ventilatory efficiency and other parameters that reflect

the combined response of the cardiovascular and respiratory systems during exercise. However, simpler submaximal tests, such as the six-minute walk test (6MWT), are also widely used in clinical practice and research thanks to their accessibility and reproducibility. Strong associations have been demonstrated between both VO_2 peak and 6MWT performance and survival, hospitalisation risk, and quality of life in patients with heart failure (HF), highlighting their prognostic value [21, 24].

In recent years, exercise-based prehabilitation has progressively gained popularity as a potential strategy for enhancing perioperative outcomes in patients with limited cardiopulmonary reserve. Prehabilitation aims to enhance physiological resilience in anticipation of surgical stress by improving functional capacity and cardiovascular performance through targeted interventions. Structured exercise programmes have been shown to improve aerobic capacity, skeletal muscle metabolism, endothelial function and autonomic balance in patients with heart failure (HF), thereby increasing cardiorespiratory reserve prior to surgery [21–23].

Prehabilitation programmes usually offer a variety of activities, including aerobic training, resistance training, respiratory muscle training and patient education. In heart failure (HF) populations, these interventions have been associated with improvements in peak VO_2 , ventilatory efficiency, and overall physical fitness. These physiological adaptations may result in an increased tolerance of surgical stress and greater resilience during the perioperative period [21, 23].

There is significant evidence supporting the benefits of exercise training in heart failure (HF). Randomised clinical trials demonstrate that structured exercise rehabilitation can significantly improve cardiac function and functional capacity. For example, in a controlled trial involving patients with heart failure and reduced ejection fraction (HFrEF), an eight-week programme combining aerobic and resistance training significantly improved functional performance. Left ventricular ejection fraction increased from 30.9% to 37.2%, and six-minute walking distance improved from 216.8 ± 40.9 m to 273.6 ± 38.4 m in the intervention group. No comparable improvement was observed in the control group [26]. These findings illustrate the capacity of structured exercise interventions to reverse aspects of functional impairment in HF and improve cardiovascular performance.

Table 1. Key studies evaluating exercise training and cardiac rehabilitation in patients with heart failure

Study	Study design	Population	Intervention	Main outcomes
Telehealth CR meta-analysis (2026) [21]	Systematic review and meta-analysis	Adults with HF	Telehealth-based cardiac rehabilitation	Improved exercise capacity and patient-centered outcomes; increased accessibility of rehabilitation
Exercise-based rehabilitation trial protocol (2026) [22]	Randomized clinical trial protocol	Patients with HF	Structured exercise-based cardiac rehabilitation	Designed to evaluate improvements in functional capacity and quality of life
Herrmann et al. (2024) [23]	Randomized pilot trial	HF patients undergoing non-cardiac surgery	Nurse-supported perioperative HF care	Lower rate of postoperative complications (25% vs. 33%), not statistically significant
Exercise training review (2025) [25]	Systematic review	Patients with HF	HIIT vs. moderate-intensity continuous training	Both modalities improve aerobic capacity; HIIT may increase VO_2 peak more in selected populations
Tele-rehabilitation studies (2025) [24]	Systematic review	Patients with HF	Home-based and telerehabilitation programmes	Comparable outcomes to centre-based rehabilitation; improved accessibility
Mahmoodi et al. (2025) [27]	Randomized controlled trial	Patients with HFrEF	8-week aerobic + resistance training	LVEF improved from 30.9% to 37.2%; 6MWT improved from 216.8 m to 273.6 m

Key studies evaluating exercise-based rehabilitation and functional capacity improvements in heart failure are summarized in Table 1.

The optimal training modality for heart failure (HF) remains an area of ongoing investigation. Both moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) have been shown to improve aerobic capacity. While some studies suggest that HIIT may produce greater improvements in VO_2 peak, moderate-intensity continuous exercise is still widely recommended due to its favourable safety profile and suitability for broader HF populations [6, 25]. Therefore, increasing total energy expenditure through sustained moderate-intensity exercise is considered a practical strategy for improving functional capacity in cardiac rehabilitation settings. Major exercise training modalities used in cardiac rehabilitation for heart failure are compared in Table 2.

Table 2. Different exercise modalities used in cardiac rehabilitation for heart failure

Training modality	Typical characteristics	Physiological effects	Evidence in heart failure	Key study
Moderate-intensity continuous training (MICT)	Continuous aerobic exercise at moderate intensity (e.g., walking, cycling, treadmill training) for 30–60 min	Improves aerobic capacity, endothelial function, skeletal muscle metabolism, and overall cardiovascular efficiency	Widely used in cardiac rehabilitation programmes due to good safety and feasibility	Exercise training modalities in patients with heart failure: comparison of HIIT and moderate-intensity continuous training. <i>J Clin Med.</i> 2025 [25]
High-intensity interval training (HIIT)	Short bursts of high-intensity exercise alternated with recovery periods	May produce greater increases in VO_2 peak compared with moderate training	Demonstrated improvement in aerobic capacity and autonomic regulation in HF populations	Exercise training modalities in patients with heart failure: comparison of HIIT and moderate-intensity continuous training. <i>J Clin Med.</i> 2025 [25]
Combined aerobic and resistance training	Integration of endurance exercise with resistance exercises for major muscle groups	Improves muscle strength, cardiac function, and overall functional capacity	Randomized clinical trial demonstrated improvement in LVEF and 6MWT after 8 weeks of training	Mahmoodi et al. (2025) [26]
Respiratory muscle training (IMT)	Inspiratory muscle exercises using resistance breathing devices	Improves ventilatory efficiency and respiratory muscle strength	Often used as an adjunct to aerobic training in HF rehabilitation programmes	Exercise-based rehabilitation trial protocol (2026) [22]
Home-based and telerehabilitation programmes	Exercise performed at home with remote supervision via telemedicine or wearable monitoring	Improves accessibility and adherence to rehabilitation programmes	Clinical outcomes comparable to centre-based cardiac rehabilitation	Telehealth CR meta-analysis (2026) [21]

Recent advances in digital health have facilitated the development of home-based and telerehabilitation programmes, expanding access to structured exercise interventions. Cardiac telerehabilitation uses remote monitoring and coaching techniques involving wearable devices and digital communication platforms to enable patients to perform supervised training in their own homes. Studies suggest that these programmes can deliver clinical outcomes comparable to those of traditional centre-based cardiac rehabilitation, while overcoming barriers such as limited access to rehabilitation centres, travel distance and mobility limitations [24].

Despite these promising findings, there is still a lack of direct evidence evaluating exercise-based prehabilitation in patients with heart failure (HF) undergoing non-cardiac surgery. Only a small number of studies have investigated perioperative optimisation strategies in this patient group. Of the open-access studies that include a control group and focus on patients with HF undergoing non-cardiac surgery, the trial by Herrmann et al. (2024) is the most frequently cited [23]. However, the intervention in that study focused on multidisciplinary perioperative management rather than structured exercise training. Although a lower proportion of postoperative complications were observed in the intervention group (25% vs. 33%), this difference was not statistically significant.

Importantly, there have been no randomised trials directly comparing exercise-based prehabilitation with standard care in patients with heart failure (HF) undergoing non-cardiac surgery. While existing studies suggest that perioperative preparation involving optimisation of medical therapy, cardiac nursing supervision and improvement of baseline functional capacity may be beneficial, robust clinical evidence remains lacking [23].

In summary, patients with chronic heart failure (HF) are particularly vulnerable in the perioperative setting. Functional capacity is a key determinant of perioperative risk, and structured exercise training has been shown to improve cardiopulmonary performance and physical fitness in HF populations [21–25]. While the concept of exercise-based prehabilitation is physiologically well-justified and supported by indirect evidence from cardiac rehabilitation studies, direct perioperative data in patients with HF remains deficient. Further research in the form of larger prospective trials is needed to determine whether systematic preoperative exercise programmes can reduce postoperative complications, shorten hospital stays and improve recovery following non-cardiac surgery.

11. Discussion

Heart failure should not be interpreted only as a reduction in left ventricular ejection fraction, but rather as a syndrome characterized by limited cardiovascular reserve and impaired adaptive capacity. The perioperative period can be seen as a controlled physiological stress test, during which even clinically stable HF may quickly become unstable. Current evidence indicates that perioperative risk is determined not only by systolic dysfunction, but also by diastolic impairment, ventricular–arterial coupling, and right ventricular performance. In this context, reliance on ejection fraction alone as a risk discriminator appears insufficient [1,9].

The increasing role of biomarker-guided risk stratification reflects a broader transition toward objective perioperative risk assessment. Elevated natriuretic peptides consistently identify patients at increased risk of myocardial injury and short-term mortality [4,14]. Although myocardial injury after non-cardiac surgery (MINS) is now recognized as clinically important, standardized perioperative algorithms that incorporate biomarker thresholds into anesthetic decision-making are still not well defined. Most recommendations are based on observational studies and expert opinion rather than large randomized trials.

Hemodynamic management remains an important factor that can influence perioperative outcomes. Avoiding prolonged intraoperative hypotension is widely recommended, but optimal perfusion pressure targets in advanced heart failure are still unclear. Current practice is mainly based on cohort studies and expert consensus statements [2,3,15]. Individualized mean arterial pressure targets based on chronic hypertension, ventricular function, and comorbidities may be reasonable, but they have not yet been confirmed in prospective studies.

Advanced monitoring techniques and echocardiographic parameters, such as global longitudinal strain, may provide additional information about myocardial function [7,13]. However, evidence that their routine use during the perioperative period improves clinical outcomes remains limited. The clinical value of these advanced technologies is therefore still uncertain.

Another important area for future research is phenotype-based management in heart failure. Although HFrEF and HFpEF differ in their underlying mechanisms, perioperative protocols are often the same for both groups. It is still unclear whether fluid and vasoactive strategies adapted to the specific HF phenotype improve clinical outcomes.

Heart failure can also be considered as a condition with reduced exercise tolerance and limited cardiopulmonary reserve. Parameters from cardiopulmonary exercise testing, such as peak VO_2 and ventilatory

efficiency, reflect cardiovascular reserve and are associated with patient prognosis. Structured exercise training can improve these parameters and quality of life in patients with heart failure [20]. The perioperative period may therefore represent a physiological stress similar to exercise testing. Including functional capacity assessment in perioperative risk evaluation may help improve clinical decision-making and patient care.

Future studies should focus on prospective trials evaluating hemodynamic targets adapted to different HF phenotypes and biomarker-guided perioperative strategies. Close collaboration between anesthesiologists and cardiologists will be important to translate new evidence into clinical practice.

In the future, perioperative management of heart failure should move beyond simple risk classification toward individualized care based on cardiovascular reserve and patient physiology.

12. Conclusions

Heart failure is associated with reduced cardiovascular reserve, which makes patients more vulnerable to perioperative stress and possible hemodynamic deterioration, regardless of ejection fraction. Current evidence shows that perioperative risk depends not only on systolic dysfunction but also on diastolic dysfunction, ventricular–arterial interaction, and right ventricular function.

Effective perioperative management therefore requires integration of structured risk stratification, optimization of guideline-directed medical therapy, and physiology-guided hemodynamic control. Although advances in biomarker assessment and monitoring technologies have refined risk identification, high-quality prospective data defining phenotype-specific hemodynamic targets remain limited.

Future improvements in perioperative care of patients with heart failure will depend on the development of multidisciplinary, evidence-based strategies that go beyond simple risk classification and support individualized cardiovascular management. In patients with chronic HF scheduled for surgery, it is advisable to assess exercise capacity (e.g., 6MWT, VO_2 peak). In cases of low fitness, consider increasing preoperative physical activity and optimizing HF treatment (hydration, pharmacotherapy, rhythm control). Such measures may theoretically shorten recovery time, reduce complications (e.g., heart failure, arrhythmias), and improve quality of life after surgery. Overall, integrating functional capacity assessment with targeted prehabilitation strategies represents a promising approach to enhance perioperative resilience in patients with heart failure. Ultimately, a shift toward personalized, physiology-driven perioperative care may translate into improved clinical outcomes and long-term patient prognosis.

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REFERENCES

- Shah, A., Sabharwal, N., & Day, J. R. (2024). Heart failure with preserved ejection fraction: Implications for anaesthesia. *BJA Education*, 24(5), 155–163. <https://doi.org/10.1016/j.bjae.2024.02.003>
- Gualandro, D. M., Masip, J., Halvorsen, S., Price, S., Rosselló, X., Chioncel, O., Peacock, W. F., Miró, Ò., Oliveira Junior, M. T., Mebazaa, A., Platz, E., Amir, O., Schaubroeck, H., Grand, J., Sionis, A., Tavazzi, G., Pöss, J., Verbrugge, F. H., Gambaro, A., ... Mueller, C. (2025). Acute heart failure in non-cardiac surgery. *European Heart Journal*, 46(40), 4042–4059. <https://doi.org/10.1093/eurheartj/ehaf559>
- Scott, M. J. (2023). Perioperative patients with hemodynamic instability: Consensus recommendations of the Anesthesia Patient Safety Foundation. *Anesthesia & Analgesia*, 138(4), 713–724. <https://doi.org/10.1213/ane.0000000000006789>
- Schmidt, G., Frieling, N., Schneck, E., Habicher, M., Koch, C., Aßmus, B., & Sander, M. (2024). Comparison of preoperative NT-proBNP and simple cardiac risk scores for predicting postoperative morbidity after non-cardiac surgery with intermediate or high surgical risk. *Perioperative Medicine*, 13(1). <https://doi.org/10.1186/s13741-024-00400-z>
- Okolo, D., Ugorji, W. S., Gopep, N. S., Oragui, C. C., Ubajaka, C. C., & Okobi, O. E. (2025). Perioperative management of anesthesia in patients with cardiovascular disease: A review of current guidelines in the United States. *Cureus*. <https://doi.org/10.7759/cureus.79355>
- Schmidt, G. F., Habicher, M., Herrmann, E. J., Kenz, M., Reichert, M., Koch, C., Markmann, M., Schneck, E., Aßmus, B., Sander, M., Frey, U., Güder, G., Meybohm, P., Reuter, D., Saugel, B., Treskatsch, S., Heuschmann, P. U., Nuernberger, C., ... Zitzmann, A. (2025). Perioperative interdisciplinary optimisation of patients with heart failure undergoing non-cardiac surgery with intermediate or high surgical risk: The rationale and study protocol for the multicentre, randomised interventional PeriOP-CARE HF trial. *Clinical Research in Cardiology*, 114(5), 523–531. <https://doi.org/10.1007/s00392-025-02626-3>
- Monaco, F., Bonaccorso, A., D’Andria Ursolo, J., Pruna, A., Lerosé, C. C., Di Prima, A. L., Barucco, G., Landoni, G., & Licheri, M. (2025). Intraoperative global longitudinal strain and strain rate as predictors of unfavorable outcome following on-pump mitral surgery: A prospective observational study. *Journal of Anesthesia, Analgesia and Critical Care*, 5(1). <https://doi.org/10.1186/s44158-025-00288-1>
- Farooq, Z., Malik, S., Bhat, M., & Farooq, S. (2025). Perioperative cardiac complications and evidence-based strategies for their management. *Cureus*. <https://doi.org/10.7759/cureus.95276>
- Kirkopoulos, A., M’Pembé, R., Roth, S., Stroda, A., Larmann, J., Gillmann, H., Kotfis, K., Ganter, M. T., Bolliger, D., Filipovic, M., Guzzetti, L., Mauermann, E., Ionescu, D., Spadaro, S., Szczeklik, W., De Hert, S., Beck-Schimmer, B., Howell, S. J., & Lurati Buse, G. A. (2025). Outcomes in patients with chronic heart failure undergoing non-cardiac surgery: A secondary analysis of the METREPAIR international cohort study. *Anaesthesia*, 80(8), 861–870. <https://doi.org/10.1111/anae.16607>
- Murthy, N. M., Yoo, T. T., Sanchez, A., Chhitu, M., Abramov, D., Gatling, J., Mamas, M. A., & Parwani, P. (2025). Preoperative diagnostic assessment of patients with cardiovascular risk factors undergoing noncardiac surgery: A 2025 update. *Methodist DeBakey Cardiovascular Journal*, 21(4), 87–100. <https://doi.org/10.14797/mdcvj.1629>
- Saetang, M., Kunapaisal, T., Limvatanalert, S., Sukitpaneenit, K., Saelim, K., Yongsata, D., Muangsong, O., Bunkerd, M., & Kampeng, S. (2026). Key predictors of 30-day mortality in non-cardiac surgery: Development, key risk factors, and calibration of a risk model. *Frontiers in Medicine*, 13. <https://doi.org/10.3389/fmed.2026.1749782>
- Li, Q., Liu, Z., He, K., Zhuang, Y., Zhang, J., Wei, B., Che, H., Zhang, B., Jiu, L., Li, J., Song, X., & Dong, W. (2025). Development and validation of an interpretable machine learning model for predicting the risk of non-cardiac surgery postoperative heart failure: A multicenter study. *Frontiers in Medicine*, 12. <https://doi.org/10.3389/fmed.2025.1666885>
- Arias, H. C. (2025). Anesthesia and intraoperative echocardiography for end-stage heart failure surgery. *Annals of Cardiac Anaesthesia*, 28(4), 379–391. https://doi.org/10.4103/aca.aca_45_25
- Deniau, B., Léopold, V., & Mebazaa, A. (2025). Accurate diagnosis of heart failure and improved perioperative outcomes. *British Journal of Anaesthesia*, 134(1), 1–4. <https://doi.org/10.1016/j.bja.2024.10.003>
- Skouri, H., Girerd, N., Monzo, L., Petrie, M. C., Böhm, M., Adamo, M., Mullens, W., Savarese, G., Yilmaz, M. B., Amir, O., Bayes-Genis, A., Bozkurt, B., Butler, J., Chioncel, O., Mebazaa, A., Merino, J. L., Moura, B., Ponikowski, P., Seferovic, P., ... Metra, M. (2025). Clinical management and therapeutic optimization of patients with heart failure with reduced ejection fraction and low blood pressure: A clinical consensus statement of the Heart Failure Association (HFA) of the ESC. *European Journal of Heart Failure*, 27(4), 707–722. <https://doi.org/10.1002/ejhf.3618>

16. Singh, A., & Mehta, Y. (2018). Heart failure with preserved ejection fraction (HFpEF): Implications for the anesthesiologists. *Journal of Anaesthesiology Clinical Pharmacology*, 34(2), 161. https://doi.org/10.4103/joacp.joacp_352_16
17. Reiterer, C., Kabon, B., Taschner, A., Graf, A., Adamowitsch, N., Horvath, K., Emler, D., Zotti, O., Hantakova, N., Hochreiter, B., Fraunschiel, M., Clement, T., & Fleischmann, E. (2025). Levosimendan for postoperative subclinical heart failure after noncardiac surgery: A randomized, double-blinded, phase III trial. *Nature Communications*, 16(1). <https://doi.org/10.1038/s41467-025-60601-y>
18. Fudim, M., Yaranov, D. M., Gupta, R., Letarte, L., Sears, S. F., Howard, B. G., Uriel, N., Raje, V., Mahmood, K., Pinney, S. P., Yeyha, A., Alam, A., Patel, P., Hicks, A., Bindra, A., Antoine, S. M., Feliberti, J., Rollins, A., Rao, V. N., ... Sayed, A. (2025). Heart failure devices: Treatment options, underutilization, and a proposed trigger system for patient referral and evaluation. *Journal of Cardiac Failure*. <https://doi.org/10.1016/j.cardfail.2025.08.019>
19. Jhund, P. S., Talebi, A., Henderson, A. D., Claggett, B. L., Vaduganathan, M., Desai, A. S., Lam, C. S. P., Pitt, B., Senni, M., Shah, S. J., Voors, A. A., Zannad, F., Solomon, S. D., & McMurray, J. J. V. (2024). Mineralocorticoid receptor antagonists in heart failure: An individual patient level meta-analysis. *The Lancet*, 404(10458), 1119–1131. [https://doi.org/10.1016/S0140-6736\(24\)01733-1](https://doi.org/10.1016/S0140-6736(24)01733-1)
20. Eleyan, L., Gonnah, A. R., Farhad, I., Labib, A., Varia, A., Eleyan, A., Almehandi, A., Al-Naseem, A. O., & Roberts, D. H. (2025). Exercise training in heart failure: Current evidence and future directions. *Journal of Clinical Medicine*, 14(2), 359. <https://doi.org/10.3390/jcm14020359>
21. Alqahtani, A. S. (2025). Telehealth-based cardiac rehabilitation for heart failure: A systematic review of effectiveness, access, and patient-centred outcome. *Medicina*, 62(1), 25. <https://doi.org/10.3390/medicina62010025>
22. dos Santos Costa, A., Barbosa, C. B., Guizilini, S., Krainer, I. B., de Marqui Moraes, P. I., Rogério dos Santos, V., & Moreira, R. S. L. (2026). REVIVE-HF: Rehabilitation with immersive virtual reality and exercise in hospitalized patients with heart failure—A randomized controlled trial protocol. *Trials*, 27(1). <https://doi.org/10.1186/s13063-026-09430-y>
23. Herrmann, E. J., Raghavan, B., Tekeste, M., Mantzsch, K., Meybohm, P., & Assmus, B. (2024). Randomized pilot trial of pre- and postoperative heart failure nurse-supported care in heart failure patients requiring noncardiac surgery—Feasibility and results. *Clinical Cardiology*, 47(6). <https://doi.org/10.1002/clc.24304>
24. Schmidt, C., Magalhães, S., Gois Basilio, P., Santos, C., Oliveira, M. I., Ferreira, J. P., Ribeiro, F., & Santos, M. (2025). Center- vs home-based cardiac rehabilitation in patients with heart failure. *JACC: Heart Failure*, 13(5), 695–706. <https://doi.org/10.1016/j.jchf.2024.09.024>
25. Eleyan, L., Gonnah, A. R., Farhad, I., Labib, A., Varia, A., Eleyan, A., Almehandi, A., Al-Naseem, A. O., & Roberts, D. H. (2025). Exercise training in heart failure: Current evidence and future directions. *Journal of Clinical Medicine*, 14(2), 359. <https://doi.org/10.3390/jcm14020359>
26. Mahmoodi, Z., Salari, A., Ahmadnia, Z., Roushan, Z. A., Gholipour, M., & Sedighinejad, A. (2025). Exercise-based cardiac rehabilitation for heart failure: Effects on echocardiographic parameters and functional capacity: A randomized clinical trial. *Annals of Medicine & Surgery*, 87(5), 2696–2701. <https://doi.org/10.1097/MS9.0000000000003006>