CardioVascular Learning Network

CATHLAB SPOTLIGHT 1

Exercise Right Heart Catheterization:

Practical Implementation and Evolving Role in Heart Failure Care

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This program is intended for physicians, cath lab teams and institutions treating heart failure patients, interested in learning more about future heart failure treatment technologies.

LEARNING OBJECTIVES

- Understand the indications and procedure of exercise right heart catheterization (eRHC)
- Learn how to establish a eRHC team, including, economic implications of the program and team member roles and responsibilities
- Identify the collaboration of specialties, needed to create a heart failure team and determine the necessary pathways for patient referrals throughout the health care system

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Dr. Houston: Consultant/Teaching Faculty – Abbott; Hemodynamic Core Lab – Aria Medical, GRADIENT Denervation

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PLANNING COMMITTEE

Planning for this activity was conducted by faculty advisors. To further support the development of the content, additional information regarding professional roles, responsibilities, and teamwork was gathered through survey input from our target audience and/or a comprehensive literature review.

HMP Education planners and staff include Samantha Bella; Brielle Calleo; MaryEllen Fama; Samantha Joy; Mary Johnson; Randy Robbin; and Andrea Zimmerman, EdD, CHCP. No HMP Education staff has disclosed a relevant financial relationship with any ineligible company (commercial interest).

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1. INTRODUCTION

Exercise right heart catheterization (eRHC) is an important tool that can help identify hemodynamic abnormalities that may not be apparent during a resting right heart catheterization (RHC). Invasive assessment with RHC is an invaluable tool for the diagnosis and etiologic evaluation of pulmonary hypertension. It also plays a critical role in the prognostication of heart failure with reduced ejection fraction (HFrEF), the evaluation of unexplained dyspnea, and the diagnostic assessment of suspected heart failure with preserved ejection fraction (HFpEF). However, even a carefully performed and interpreted resting RHC may offer an incomplete view of a patient's underlying physiology. These studies, typically conducted in the supine and resting state, cannot be expected to capture the dynamic abnormalities responsible for symptoms that occur during exertion. In this context, eRHC provides critical insight, allowing clinicians to assess cardiopulmonary responses under physiologic stress and enhancing diagnostic precision across a range of conditions.

Exercise right heart catheterization has become increasingly central to the diagnostic evaluation of HFpEF. Many patients with HFpEF undergo their diagnostic RHC while already receiving diuretics, which can reduce filling pressures to a normal range and obscure diagnostic findings. In addition, a subset of patients with HFpEF exhibit abnormal hemodynamics only during exertion, known as exercise-induced left atrial hypertension. In both scenarios, the underlying pathophysiology may be missed without the addition of exercise-based assessment.

eRHC enables a more complete hemodynamic evaluation assessing parameters including the peak pulmonary arterial wedge pressure (PAWP), the PAWP to cardiac output (CO) relationship, and PAWP indexed to workload and body weight. These data can uncover the characteristic physiologic abnormalities of HFpEF and support a definitive diagnosis. In the sections that follow, we outline the logistics of eRHC performance and practical strategies for building a successful eRHC program.

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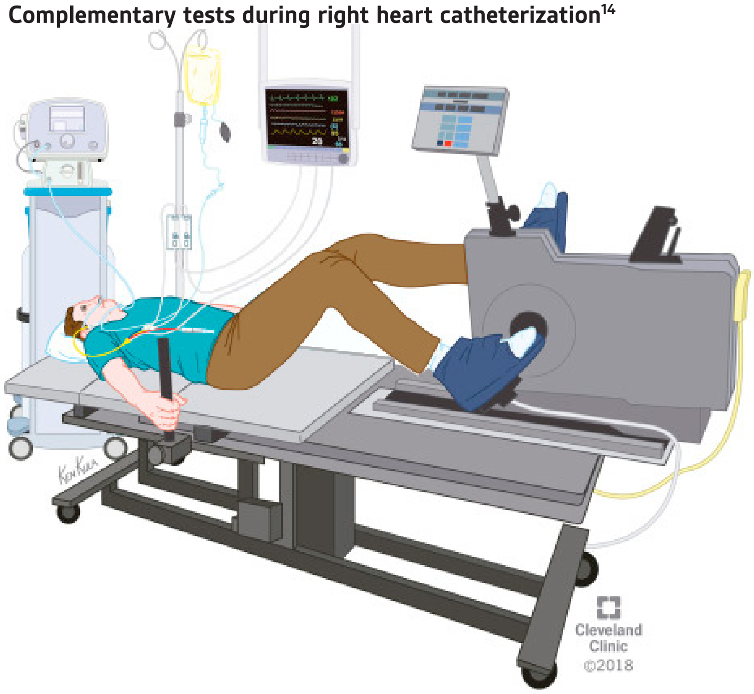
Figure: Complementary tests during right heart catheterization[14]



2. BUILDING THE eRHC TEAM

Crucially, eRHC is best viewed as a team-based procedure. To establish a reliable, high-quality program that produces consistent diagnostic results, active engagement and coordination from each team member are essential. Adding exercise to a standard RHC requires additional time, physical effort, and logistic complexity, making team buy-in critical.

A dedicated clinical champion who focuses on efforts on provider and staff education can play a vital role. At our institution, advanced heart failure cardiologists spearheaded the eRHC effort, driven by a strong clinical focus on HFpEF care and accelerated by involvement in clinical trials that required eRHC for patient inclusion.

The exact team composition may vary depending on institutional resources and provider preferences, but at a minimum, three team members are typically required to perform the procedure safely and effectively:

- A cardiologist with expertise in the performance and interpretation of eRHC should lead the study.
- A nurse or technician should be present to monitor the case and record key hemodynamic data. Given the real-time nature of eRHC, this team member should be well-versed in the exercise protocol, familiar with the expected pacing of measurements, and understand how the clinical team prefers to have the data presented and reviewed.
- A second nurse should assist either scrubbed into the procedure or operating in a circulator role to help monitor vital signs, oversee exercise bike performance and resistance progression, and manage sample testing (e.g., venous and/or arterial oxygen saturation in real time).

If cardiometabolic data, such as gas exchange, are being measured during eRHC, a nurse or exercise physiologist specializing in that equipment is required.

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3. IMPLEMENTING AN eRHC PROGRAM: PRACTICAL STEPS, TRAINING, AND LOGISTICS

Establishing an eRHC program requires institutional commitment to support the necessary infrastructure, including equipment setup, staff training, resource allocation—and critically—a physician or hemodynamics champion to lead the effort. The Heart Failure Society of America and Society for Cardiovascular Angiography & Interventions emphasize that accurate evaluation of conditions such as advanced heart failure, pulmonary hypertension, and valvular heart diseases depends on clearly defined clinical indications for both resting and exercise testing. Successful implementation also requires standardized protocols and close multidisciplinary collaboration between key stakeholders.[1,2] These typically include advanced heart failure cardiologists (or non-interventional invasive specialists), interventional cardiologists, pulmonary hypertension specialists, cath lab nurses and technicians, and in some cases, exercise physiologists. Taken together, these elements are the foundation for consistent patient selection, protocol development, and safety monitoring, all critical to the safe and effective launch of an eRHC program.

Exercise right heart catheterization requires experienced staff, structured data collection protocols, dedicated exercise equipment, and, at times, additional procedural time to ensure accurate hemodynamic assessment under both resting and exercise conditions. Cath lab personnel, including physicians, nurses, and technicians, should be trained in both resting and hemodynamic protocols, with a strong understanding of expected waveforms across cardiac and pulmonary chambers. Team members must also be able to recognize abnormal waveforms during exercise and apply appropriate troubleshooting techniques, such as identifying arrhythmias or adjusting for catheter malposition. Training may include hands-on workshops at simulation labs or observational clerkships at experienced centers.[3,4] Essential equipment includes supine or upright cycle ergometers, with most centers using procedural table-mounted supine bikes. For gold standard cardiac output measurements, a metabolic cart is necessary for directly measuring oxygen uptake via the Direct Fick method.[1] To maintain staff competency in safety protocols, regulatory emergency scenario rehearsals, such as management of arrhythmia or adverse exercise-induced symptoms, can help ensure confidence and preparedness when performing eRHC in high-risk patients.

Implementing an eRHC program requires thoughtful planning across multiple domains, including patient selection, scheduling, room setup, equipment storage, and staffing ***(Table)***. Successful catheterization labs provide sufficient space to accommodate either on-table or upright cycle ergometers alongside hemodynamics monitors. Most centers favor table-mounted cycle ergometers to allow patients to exercise while remaining instrumented on the table, although upright bicycle ergometers provide certain advantages depending on patient-specific factors.[5]

Venous access is typically obtained via the right internal jugular vein or right brachial vein to facilitate patient movement during exercise. Importantly, right internal jugular vein access also enables the use of multiport catheters to measure biventricular compliance, allowing simultaneous measurements of right atrial, pulmonary artery, and

Table: Considerations for Implementing an eRHC Program

FACTOR	CONSIDERATIONS
Procedural space	Ensure the cardiac catheterization lab has sufficient space for storing and utilizing a supine or upright cycle ergometer.
Equipment	Use a table-mounted supine or upright bicycle ergometer with dynamic workload capabilities. Include dual-port pulmonary artery catheters for multi-chamber pressure measurements. Optional: metabolic cart for gas exchange and Direct Fick cardiac output calculation.
Personnel	A multidisciplinary team may include advanced heart failure cardiologists (or non-interventional invasive specialists), interventional cardiologists, pulmonary hypertension specialists, cath lab nurses and technicians, and exercise physiologists (in some centers). Ensure all team members are trained in hemodynamic measurements and exercise and safety protocols.
Training	Develop protocols for resting and exercise hemodynamic assessments. Train staff to recognize abnormal waveforms (e.g., catheter malposition, arrhythmias). Use simulation labs, hands-on workshops, or clerkships at experienced centers. Emphasize quality waveform acquisition, especially at peak exercise.
Scheduling	Allocate longer procedure times due to test complexity and duration. Use ergometers with workload increments every 2–3 minutes; most tests complete in 10–15 minutes. Plan for 15–30 minutes longer than a standard RHC.
Safety measures	Apply strict patient selection and screen for contraindications (e.g., uncontrolled arrhythmias, severe valvular stenosis, severe pulmonary arterial hypertension or orthopedic limitations). Establish and rehearse emergency protocols to ensure staff readiness during testing.

pulmonary arterial wedge pressures during exercise.

Cycle ergometers with dynamic workloads that increase every 2-3 minutes (measured in Watts) allow most exercise tests to be completed within 10-15 minutes. Accordingly, procedure scheduling should account for approximately 15-30 additional minutes compared with standard right heart catheterization. Some centers choose to bundle eRHC cases on specific days to accommodate the extended time per case and to ensure that specialized personnel—such as advanced heart failure/hemodynamics specialists, trained nurses and technicians, and exercise physiologists—are available.

As with all catheterization procedures, continuous patient monitoring by electrocardiography, invasive pressure measurement and reporting, and oximetry is essential. If systemic arterial monitoring is required, additional instructions should be provided to procedural and recovery staff for managing radial arterial access.[4]

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4. CLINICAL AND ECONOMIC BENEFITS OF eRHC

Establishing an eRHC program entails upfront investments in equipment and specialized training. However, the ability to characterize complex cardiopulmonary disease states through dynamic hemodynamic assessment may provide important clinical and financial returns. eRHC enables precise phenotyping of heart failure syndromes, such as HFpEF and pulmonary arterial hypertension, as well as the identification of occult disease and candidacy for advanced therapies.[1] This includes facilitating enrollment in clinical trials, detecting unrecognized valvular disease in patients who may benefit from mitral transcatheter edge-to-edge repair (TEER), or guiding earlier intervention with transcatheter aortic valve replacement (TAVR) in asymptomatic patients with moderate-to-severe aortic stenosis and exercise-induced pulmonary hypertension.

When integrated into a multidisciplinary program, eRHC can support timely decision-making and personalized management that may ultimately reduce heart failure-related hospitalizations. In this context, the case for return on investment becomes tied not only to diagnostic precision, but also to downstream therapeutic impact, enrollment in clinical research, and optimization of resource utilization. Investment in training and workflow optimization further enhances operational efficiency and strengthens the long-term value proposition of the program.

Reimbursement for eRHC is supported under existing cardiac catheterization billing codes. Standard CPT codes include diagnostic RHC (CPT 93451 or related), the add-on for physiologic exercise study (93464), and, when applicable, the add-on for cardiopulmonary exercise testing if gas exchange is measured using a metabolic cart to derive Direct Fick parameters (94621).

Coverage for eRHC is typically limited to certain indications, most commonly unexplained dyspnea and pulmonary hypertension, and is subject to local coverage determinations by Medicare Administrative Contractors and private insurers. While many institutions initially require startup funding to launch an eRHC program, the potential for downstream referrals to procedures can help strengthen institutional support. In summary, although eRHC requires upfront investment, it is likely to achieve financial sustainability over time, given its role as a valuable clinical tool for evaluating and managing complex cardiovascular conditions.

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5. COLLABORATIVE APPROACH TO CARE

Like many aspects of modern medicine, successful cardiovascular care relies on collaboration, and the management of heart failure is no exception. As treatment options have evolved beyond pharmacologic approaches, a growing array of structural interventions now aim to improve quality of life in patients for whom medical therapy alone is insufficient. Emerging therapies include left atrial shunts, left ventriculoplasty, and implantable endovascular cardiac monitors.[6] Advancing such therapies safely and effectively requires close coordination between advanced heart failure practitioners and interventional cardiologists, combining clinical insight with technical expertise.

This collaborative model between advanced heart failure specialists and interventional cardiologists has become increasingly central to the care of heart failure patients, as demonstrated in recent clinical trials.[6] Reflecting this trend, an increasing number of cardiology fellows are pursuing joint training in both subspecialties, contributing to the emergence of the hybrid field of interventional heart failure.[7] This growing interest is undoubtedly fueled by the promise of future percutaneous therapies and the evolving landscape of structural interventions in heart failure care.

Involvement of heart failure physicians in catheterization lab procedures directly promotes the use of invasive hemodynamics to guide patient optimization and therapy selection. In turn, the increased frequency of hemodynamic studies, performed in collaboration with engaged heart failure physicians, enhances interventional cardiologists' proficiency and familiarity with advanced hemodynamic assessment. As both specialities integrate these tools more fully in their practice, there is a natural expansion in cath lab volume for invasive hemodynamic procedures, supporting the management of both outpatient heart failure and inpatient shock patients.

Interdisciplinary specialty care of heart failure patients extends far beyond the collaboration between advanced heart failure and interventional cardiology. Ongoing coordination with electrophysiologists, cardiac imaging specialists, pulmonologists, and others remains essential. This reliance on subspecialty expertise will only deepen as the number of therapies available continues to expand.

A typical heart failure patient may engage with multiple specialists along their care journey:

- The primary cardiologist initiates diagnoses and guides initial medical therapy;
- An interventional cardiologist performs cardiac catheterization and, when indicated, coronary revascularization;
- An electrophysiologist will evaluate for heart rhythm management, or cardiac resynchronization;
- Cardiac imaging specialists contribute multimodality imaging throughout the diagnostic and therapeutic process;
- An advanced heart failure specialist may conduct additional hemodynamic evaluation, such as eRHC;
- When device-based therapies are considered, detailed structural and functional insights from imaging and interventional teams inform selection and procedural planning.

While the pathway varies from patient to patient, one point is clear: effective management of heart failure hinges on a collaborative, multidisciplinary team.

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6. PATIENT REFERRAL PROCESS

Dyspnea and fatigue, two of the most common patient complaints, frequently prompt clinic visits across a range of specialties; many of which can benefit from the insights provided by eRHC. The most common referring providers are cardiologists, pulmonologists, and primary care physicians. Referrals may arise based on symptoms alone or as part of structured disease-specific programs such as those focused on heart failure, pulmonary hypertension, valvular heart disease, or dysautonomia.

eRHC offers diagnostic and prognostic value in a variety of clinical contexts. For example, its utility has been demonstrated in patients with pulmonary hypertension due to aortic or mitral valvular disease, those with group 1 pulmonary hypertension (e.g., scleroderma), and individuals with multifactorial dyspnea in the context of intrinsic lung disease.[8-12] In these cases, eRHC can refine diagnosis, clarify disease mechanisms, and inform risk stratification, supporting tailored treatment strategies across a spectrum of complex cardiopulmonary conditions.

Opportunities to build rapport with referring providers and demonstrate the clinical value of eRHC are plentiful. Increasingly, eRHC is being integrated into standardized diagnostic pathways within various specialty programs. For instance, in advanced heart failure programs, eRHC can help identify patients at highest risk of hospitalization or death, particularly when evaluating candidacy for heart transplantation or left ventricular assist device therapy.[13] Similarly, heart valve centers may employ eRHC for risk stratification in patients with "asymptomatic" valvular heart disease who may, in fact, benefit from early surgical or transcatheter intervention.[9]

Integrating eRHC into the diagnostic workflow of high-volume or rapidly expanding programs provides objective data that supports both clinical decision-making and treatment planning. In practical terms, the physiologic data obtained from eRHC can also strengthen documentation for insurance approvals, providing needed advocacy for patients requiring advanced therapies.

Another increasingly utilized model is the symptom-centered clinic. For example, a dedicated "dyspnea clinic" focuses on patients presenting with shortness of breath and employs an interdisciplinary approach involving cardiologists, pulmonologists, metabolic health specialists, and internists. These clinics often follow a structured, algorithmic workup, in which eRHC plays a critical role as a diagnostic pivot point when noninvasive testing is inconclusive.

Not all referrals, however, arise from formal programs. Many originate from frontline clinics managing patients with persistent but unexplained symptoms. For a primary care provider faced with a patient experiencing exertional fatigue, narrowing a broad differential diagnosis is both challenging and time-consuming. In these scenarios, eRHC can be a valuable tool that streamlines diagnostic efforts and offers clarity. Proactively advertising eRHC services—with a concise description of appropriate indications such as dyspnea on exertion, exercise intolerance, or unexplained fatigue—can serve as a much-needed clinical "lifeline" for practitioners navigating complex cases that often involve a cascade of inconclusive specialty consultations.

As with any strong referral network, effective communication and feedback are key. While efficient front desk operations help ensure smooth logistics, the true foundation of successful collaboration lies in clinical reports and direct provider-to-provider communication. These touchpoints offer critical opportunities to build rapport with referring clinicians, educate them on the interpretation and utility of eRHC findings, recommend next diagnostic or consultative steps, and encourage future referrals. Additionally, performing a value analysis of your eRHC program to stakeholders—highlighting referral patterns, reimbursement data, and downstream utilization of consultations, imaging, or therapies (i.e., the "halo effect")—can serve as a compelling demonstration of the program's clinical and institutional impact. Such analyses can be instrumental in securing ongoing support, expanding resources, and elevating the profile of the program.

Finally, for institutions engaged in clinical research, proficiency in eRHC offers a distinct advantage. Many investigational heart failure devices have required eRHC as part of their trial protocols. Having physicians and staff who are skilled in performing these studies not only facilitates successful participant enrollment but also positions the site as a preferred partner for future trials. An established eRHC referral network provides a ready pool of potential participants, streamlining recruitment across studies. Given the range of pathologies that can be characterized through eRHC, this capability supports research across multiple clinical domains and specialties, further justifying shared investment across different cost centers. As demonstrated in pivotal heart failure trials over the past decade (e.g., COAPT vs MITRA-FR for mitral TEER), precise phenotyping and disease staging can significantly influence trial outcomes. The more sophisticated and specific our diagnostic approach, the greater the likelihood of matching the right therapy to the right patient.

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7. CONCLUSION

Exercise right heart catheterization (eRHC) is a powerful diagnostic tool that enhances physiologic understanding beyond what resting measurements can reveal. From its critical role in unmasking exercise-induced left atrial hypertension in HFpEF to its utility in refining diagnoses across valvular, pulmonary, and systemic conditions, eRHC enables more precise, individualized care. Establishing a successful eRHC program requires institutional investment, a multidisciplinary team, and thoughtful coordination of training, logistics, and scheduling. When integrated effectively, eRHC not only informs clinical management but also opens pathways to advanced therapies, clinical trial participation, and long-term cost-effective care.

Looking ahead, the role of eRHC in patient care is poised to expand. As structural and device-based heart failure therapies evolve, and as trials increasingly demand physiologic precision in patient selection, eRHC stands to become a cornerstone of modern cardiovascular evaluation. Ongoing efforts to standardize protocols, refine referral pathways, and embed eRHC into interdisciplinary care models will be essential to realizing its full clinical and institutional potential. In this landscape, eRHC offers more than diagnostic clarity—it provides a strategic advantage in delivering the right therapy to the right patient, at the right time.

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