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Heart Failure with Reduced Ejection Fraction

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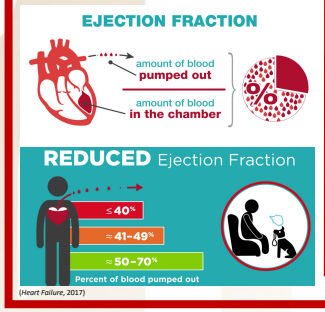
Introduction

Heart failure (HF) is a complex disease that requires a high-level understanding of pathophysiology and physics. The basic idea behind HF is an inadequate flow of oxygenated blood forward due to failure of the heart to pump effectively. As the disease progresses to an advanced stage it can be increasingly devastating to patients' activities of daily living.

Advanced stage hart failure is defined by Severino et al. as un unstable condition that no longer responds to standard treatment (2019). Treating end stage heart failure can be both complex yet common in the intensive care so it's important for nurses to understand the pathophysiology of the disease. Death often accompanies this disease without early interventions to decrease symptoms and prolong a patient's life span.

Heart failure has been significantly studied but is a difficult topic for students to understand. With increasing number of admissions nurses need a deeper understanding of the disease process.

- Heart failure accounts for an abundance of hospital admissions and mortality yearly; however, as heart failure treatments continue to advance, incidence of death continues to decline (Gummert et al., 2019)
- The late stages of heart failure can require decisions about quality of life (Servino et al., 2019)
- The end-result of the disease, when medication alone don't work is a heart transplant, ventricular assist device, or palliative care (Servino et al, 2019)



(*Heart Failure*, 2017)

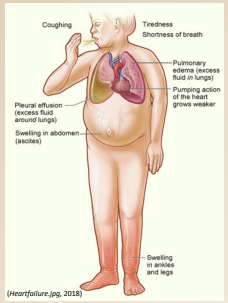
Signs and Symptoms

Many of the signs and symptoms are related to a backup of blood flow from the corresponding side of the heart. The right side is specifically related to fluid overload into the body while left sided creates fluid buildup into the lungs. Theses systems are however interrelated and failure of one often results in failure of the other. Bosch et al. resulted that while both HF with reduced EF and HF with preserved EF led to right sided failure, the reduced EF group had a worsened symptoms (2017).

Left Sided

- Pulmonary congestion
- Cough
- Crackles
- Wheezes
- Tachypnea
- Pink frothy sputum
- Orthopnea
- Tachycardia
- Restlessness
- Exertional dyspnea
- Fatigue
- Cyanosis

(*Heart Failure*, 2017)



(*Heartfailure.jpg*, 2018)

Testing

- Vital signs to assess hypotension, tachycardia, tachypnea
- EKG to assess ischemia and ventricular hypertrophy
- Right heart catherization to measure heart chamber pressure
- Swan-Ganz Catheter for continued measurement of heart chamber pressure and mixed venous blood gases (Dunlay & Colucci, 2020)
- Echocardiogram to assess size and ejection fraction
- Chest X-ray to assess lung function
- NT-pro BNP to assess fluid overload and lactic acid level for oxygen delivery

(*wan et al.*, 2019)

Classification

New York Heart Association (NYHA) Functional Classification

1. No limitation of physical activity, no fatigue, palpitation, or dyspnea (I)
2. Slight limitation of physical activity, ordinary amount of physical activity results in fatigue, palpitation, dyspnea (II)
3. Marked limitation of physical activity, Less than ordinary activity causes fatigue, palpitation, or dyspnea (III)
4. Unable to carry on any physical activity without discomfort, symptoms at rest (IV)

(*Heart Failure*, 2017)

Physics

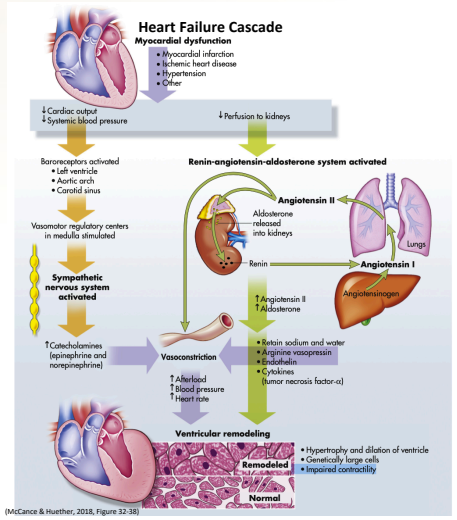
Frank-Starling's curve, Ohm's, Poiseulle's, and Laplace's laws are all used to describe contractility, flow, and resistance and remodeling of the ventricle. Ohm's law defined by Nagelhout is the correlation of flow of electricity between electrical pressure and resistance to the flow (2017). Nagelhout defined Poiseulle's law as the amount of fluid flowing through a tube in relation to pressure across the tube, the radius, length, and viscosity (2017). Ohm's equation is rewritten in applied physics to demonstrated that the flow (CO) is directly related to a pressure difference and inversely related to resistance. Poiseuille's law demonstrated that the largest impact on resistance to flow is the radius of the tube. When applied to the body, doubling the radius has a 16-fold increase in flow. This mechanism directly relates to the afterload the heart must overcome to pump blood forward. Nagelhout described Frank-Starlings mechanism as an increase in left ventricle preload that will increase contractility due to the stretch of the myocardium but only to a certain extent (2017). Nagelhout described the Law of Laplace as the relationship of wall tension to pressure and radius in cylinders (2017). This law comes into play when understanding the mechanisms that create ventricular remodeling of the left ventricle myocyte. Understanding the pressure-volume relationship is important to understand the pathophysiology of heart failure.

Pathophysiology

Left sided heart failure with reduced ejection fraction (EF) is defined as an EF < 40% with an inability of the heart to produce a cardiac output that adequately perfuses organs (Mccance & Huether, 2018). When the left side of the heart to doesn't contract properly a decrease cardiac output occurs creating a back-up in oxygenated blood flow. As the disease worsens, organ systems begin to suffer from lack of oxygen and the body goes into cardiogenic shock.

Cardiac output is determined by the volume of blood pumped out of the left ventricle (stroke volume) multiplied by a heart rate to determine the liters per minute of blood flow (Mccance & Huether, 2018). Cardiac output is further determined by three key values, preload, contractility, and afterload. Preload is defined as the stretch or length of left ventricular myocardial fibers at end-diastole (Colucci & Cohn, 2020). Contractility is defined as the force generated at any given preload (Colucci & Cohn, 2020). Afterload is defined as the impedance during ejection (Colucci & Cohn, 2020).

The Pathophysiology of heart failure with reduced EF is related to an impaired cardiac contractile function. The most common cause of this type of heart failure is a myocardial infarction however myocarditis and cardiomyopathies, increased myocardial workload can all contribute (Mccance & Huether, 2018). The result is a myocardium that is unable push blood forward creating fluid to backup and an increased preload. Nagelhout mentioned that too much preload results in the downslope of Frank-Starlings curve creating a decrease in contractility due fluid overload (2017). As cardiac output falls, the bodies sensing receptors sense the changes and sets off a cascade of events. Sympathetic output attempts to restore cardiac output by increasing the contractility and heart rate (Colucci & Cohn, 2020). The decreased flow to the kidneys creates an increase in renin leading to the cascade of the renin-angiotensin-aldosterone and an increase in sodium, water, and blood pressure (Nagelhout et al., 2017). These mechanisms further worsen preload and increase afterload. The heart then begins to compensate by allowing hypertrophy of the myocytes that innervates the left ventricle (Colucci & Cohn, 2020). The Law of Laplace describes wall thickness being indirectly related to wall stress therefore increasing the size of the muscle decreases the stress placed on the heart to overcome afterload. This unfortunately decreases the amount of blood that can fit inside the ventricle further complicating the CO.



(McCance & Huether, 2018, Figure 32-38)

Medications

Preload reduction

- Diuretic therapy (Loop diuretics, thiazides, mineralocorticoid receptor antagonists) – Decreases total body fluid (Dunlay & Colucci, 2020)

Afterload Reduction

- Angiotensin receptor-neprilysin inhibitor (ARNI), angiotensin converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARBs) – One of these agents used at a time to slow the remodeling of the left ventricle and improve survival (Meyer, 2020) – Should titrate to higher doses if tolerated for a reduction in worsening of heart failure (Turgeon et al., 2019)
- Beta-blocker – only after patient condition has stabilized – start low and titrate up to improve filling time and decrease afterload (Meyer, 2020)
- Hydralazine plus Nitrates – used to decrease resistance to flow, shown to provide symptomatic and mortality benefit (Meyer, 2020)
- Nitrates – Reduction in afterload (Dunlay & Colucci, 2020)

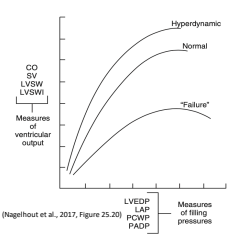
Contractility improvement

- Inotropes – dobutamine or milrinone – Increases squeeze on heart and heart rate while also decreasing afterload by lowering blood pressure - should only be used in acute decompensated HF (Dunlay & Colucci)

Treatments

- Fluid restriction of 1.5 to 2.0 L/day (Dunlay & Colucci, 2020)
- Impella/Balloon pump/ECMO – used as acute management of heart failure in an ICU setting to improve CO (Dunlay & Colucci, 2020)
- Left Ventricular Assist Device (LVAD) – used to improve quality of life for those who are unable to receive transplant or as a bridge in those on the transplant list
- Heart Transplant – gold standard to fix heart failure, improved survival and quality of life (Dunaly & Colucci, 2020)
- Palliative Care – beneficial for those who already have diffuse end organ damage and unable to benefit from advanced therapies (Serverino et al., 2019)

Relationship of pressure to output



(Nagelhout et al., 2017, Figure 25.20)

Nursing Implications

- Nurses are first line caregivers and therefore recognize changes in patients prior to others. Heart failure can decompensate quickly, the nurse's job is to recognize the signs and symptoms and call the appropriate provider as soon as possible to decrease ischemia to other organs and increase survival chance of the patient.
- Understanding the concepts of preload, contractility, and afterload as well as how each medication affects the heart can lead to better patient care.
- Nurses need an in-depth hemodynamic understanding to titrate medications based on Swan-Ganz catheter therapy.
- Specialized treatments continue to advance such as Impella and LVAD, nursing education needs to advance with it.
- Heart failure can be complicated to treat, it takes an interdisciplinary approach. Some institutions have specialized Heart Failure teams. Advocate for the use of those doctors to manage the heart failure regimen.
- Palliative care should be implemented early in the hospital course of heart failure and work with the nurse to help patients determine their best treatment route (Dunlay & Colucci).
- Educating patients about the disease process, medications, treatments, and lifestyle changes are an important part of the nursing profession to decrease readmissions.

Conclusion

- Heart failure is never going to be eradicated; however, the current understanding of the disease process, prescribed treatments, and interventions need to continue to improve to save more lives
- As the population continues to grow older, more instances of heart failure will occur
- A deep understanding of physics and pathophysiology can help a nurse prevent adverse effects of the disease process and medications involved
- The pathophysiology includes an initial sympathetic and hormonal response, over-use of these maneuvers leads to cardiac remodeling, decreased cardiac output, and eventually failure to compensate for demand (Wan et al., 2019)
- Sacubitril-valsartan (Entresto) – ARNI has shown to reduce mortality and hospitalizations compared with the proven dose of ACE inhibitors (Meyer, 2020)
- A LVAD can improve quality of life and increase lifespan compared to standard therapy treatment of end stage heart failure, however they do have adverse risks (Gummert et al., 2019)
- Heart transplant is the gold standard for treatment (Gummert el al., 2019)
- Palliative care can be beneficial for those patients whose pathophysiology is too compromised throughout the body to reverse (Serverino et al. 2019).

References

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