Gregory S. Thomas, L. Samuel Wann, and Myrvin H. Ellestad (eds.) Ellestad's stress testing: Principles and practice; 6th Edition

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Stress testing is an essential tool that has been in use for almost a century. While mostly perceived as a test for detecting inducible myocardial ischemia, stress testing provides a wealth of diagnostic and prognostic information. For example, stress testing can shed light on the timing of onset and offset of symptoms and ischemia related to exertion, functional capacity, arrhythmia, hemodynamic changes, and autonomic function. In patients who are able to perform the test, exercise stress is superior to pharmacologic stress since it provides this incremental information. It is fascinating that despite the gargantuan advancement in imaging, exercise stress testing without imaging performed using protocols developed in the 1950s and 1960s continues to have a major role in the management of patients who are capable of adequately exercising and have a relatively normal electrocardiogram (ECG) to this day.

''Ellestad's Stress Testing: Principles and Practice; 6th Edition'' (Oxford University Press; Dec 12, 2018; 608 pages; ISBN-10: 0190225483; ISBN-13: 978-0190225483; hardcover $160) Edited by Drs. Gregory S. Thomas, L. Samuel Wann, and Myrvin H. Ellestad is a comprehensive textbook on stress testing written for the benefit of trainees as well as established providers who have been performing the test for many years. The text reviews the physiologic and metabolic considerations of stress tests but also emphasizes the practical aspects of the test, its role independently and accompanying imaging, its application to specific populations, as well as its future. This is the sixth edition of this textbook; the first addition was published 44 years ago (1975), and the immediate prior edition 16 years ago (2003). The current textbook is not an updated version of the prior edition but rather a rewritten textbook by new editors and authors, with the introduction of significant new materials and chapters.

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SECTION I

This is an introduction to stress testing that includes 2 chapters.

Chapter 1: History of Exercise Stress

The first chapter is a wonderful review of the history of stress testing that starts with the introduction of the string galvanometer in 1902. The chapter includes details on the development of stress testing, the identification of the ECG leads used, standardization of the test over time, and the introduction of the protocols currently in use. The chapter is rich with figures and references that are of great value to anyone interested in the field.

Chapter 2: Physiology of Cardiac Ischemia

The chapter is an expansive review on the physiology of cardiac ischemia which is essential as a background for the entire book.

SECTION II

This section focuses on practical considerations in stress testing and includes 11 chapters.

Chapter 3: When to Use Exercise Testing—Indications, Guidelines and Appropriate Use Criteria

The chapter reviews the accepted indications for exercise stress testing without accompanying imaging according to current guidelines and appropriate use criteria for the diagnosis of coronary disease and for risk stratification. Details are provided regarding the use of stress testing in conjunction with risk scores and pathways currently used for the assessment of patients with chest pain.

Chapter 4: Contraindications, Risks, and Safety Precautions for Stress Testing

The absolute and relative contraindications of stress testing as well as the indications to terminate testing are reviewed. The requirements and protocols required for a culture of safety are highlighted throughout the chapter. The chapter also includes case presentations of patients who died during stress testing and lessons are drawn in the discussion of each case.

Chapter 5: Parameters to be Measured During Exercise

This is a detailed chapter that includes information on all the parameters that should be assessed during stress tests and the different leads used for ECG monitoring. A nice discussion is included regarding the estimation of METs for the different protocols, including Bruce and Ellestad, and the effect that holding the rail has on energy expenditure.

Chapter 6: Blood Pressure Measurements During Exercise Testing

This chapter reviews the different non-invasive and invasive methods available for assessment of blood pressure including automated ones and the correlation of these to central pressures. The chapter explains the normal blood pressure response to exercise and the prognostic information that can be obtained from monitoring blood pressure during exercise and recovery. There is an extensive discussion of exercise-induced hypotension that provides very important information to anyone monitoring or interpreting hemodynamic data during stress testing.

Chapter 7: Stress Testing Protocols

The chapter reviews the development of the different stress protocols so that clinicians can better understand the protocols that are in use today. While most clinicians use a single protocol in their practice, the chapter makes a strong argument for personalizing the selection of the protocol to better fit the patient.

Chapter 8: The Ellestad Protocol

In addition to providing a detailed description of the eponymous protocol, this chapter provides important and detailed practical information regarding the performance of stress tests in general that would be of great value even to clinicians who are using other protocols.

Chapter 9: Interpretation of the ECG During Exercise and Recovery

This chapter provides essential guidance on how to interpret ECG changes during exercise and recovery. In addition to an excellent discussion regarding ST changes and what constitutes an ischemic response (the reader will appreciate a fascinating discussion regarding upsloping ST depression), the chapter includes information on a multitude of unconventional ECG markers that are worthy of attention.

Chapter 10: Rhythm and Conduction Disturbances in Stress Testing

Arrhythmias are not infrequent during stress testing. It is, therefore, essential that providers are comfortable in recognizing the different arrhythmic manifestations that can occur with exercise and the implications of these findings on prognosis. The reader will appreciate the inclusion of a very useful section to help differentiate ventricular tachycardia from supraventricular tachycardia with aberrancy when a wide complex rhythm is encountered during the test.

Chapter 11: Predicting Prognosis with the Exercise Test: Putting It All Together

The chapter describes the main determinants of prognosis of the test including a review of the data

supporting the use of physical fitness, ST changes (including the Kligfield–Okin ΔST/HR index), heart rate, heart rate response, heart rate recovery, angina and composite scores such as the Duke Treadmill Score as prognostic indicators.

Chapter 12: Supervision of Stress Testing by Nonphysicians

While nonphysicians supervising stress tests (including cardiovascular registered nurses, advanced practice nurses, and nurse practitioners) will benefit from the material included in all chapters of this book, this chapter reviews the specific competencies required by these providers, their role in supervising the test and the role of the physician. It also includes practical sections on how to perform a clinical review prior to the test and the potential drug interactions with stress testing.

Chapter 13: Exercise Testing in a Limited Resource Environment: A Perspective from Egypt

The chapter reviews the optimal role that stress testing can play in a limited resource environment and its cost effectiveness in this setting.

SECTION III

This section discusses the role of the different cardiac imaging modalities in stress testing and is composed of 6 chapters.

Chapter 14: Making Clinical Decisions Based on Treadmill Exercise Testing Without Imaging

The chapter discusses clinical decision-making using treadmill exercise testing without imaging and the economic impact and implications of stress testing. It also highlights the cost of stress imaging performed each year and discusses possible ways to utilize treadmill data to reduce need of imaging.

Chapter 15: Nuclear Cardiology

The chapter familiarizes the reader with the diagnostic performance measures of myocardial perfusion imaging (MPI), the importance of heart rate response, conversion of exercise to pharmacologic MPI, timing of radioisotope injection, issue of radiotracer plateauing with higher myocardial blood flow, discordance between ECG and MPI, use of computed tomography (CT) angiography in inconclusive MPI studies, individual vasodilators and pitfalls, and discusses several protocols and challenges of same day MPI SPECT. In addition, it provides an insightful comparison of positron emission tomography (PET) vs. single photon emission computed tomography (SPECT) imaging from technical and feasibility standpoints and highlight advantages and pitfalls of both. The chapter is loaded with case presentations that are accompanied with images.

Chapter 16: Stress Echocardiography

The chapter starts by acquainting the reader with the history of stress echocardiography and stress echocardiographic protocols. The chapter discusses image analysis and reporting, diagnostic performance and use of strain and three-dimensional echocardiography with stress testing.

Chapter 17: Stress Cardiac Magnetic Resonance Imaging

The chapter reviews the role of stress cardiac magnetic resonance (CMR) for myocardial function and perfusion. The authors also discuss strengths and weaknesses of CMR as compared to other stress modalities.

Chapter 18: Stress X-ray-Computed Tomography

The chapter provides a historical perspective of cardiac CT and discusses cardiovascular uses of CT. It also briefly discusses the role of stress myocardial perfusion CT and compares it with SPECT.

Chapter 19: Combining Coronary Artery Calcium Scanning and Treadmill Exercise in the Assessment of Coronary Artery Disease: The Treadmill Calcium Test

The chapter relates the history of coronary artery calcium (CAC) score, discusses the cut offs and interpretation of CAC scores, and provides a perspective on the importance of obtaining good quality CAC scan. The chapter also acquaints the reader with uses of CAC score to risk stratify patients, followed by how CAC can promote compliance among patients, help in decision-making with respect to referrals for stress testing and guide therapy. An insightful discussion is included on the power of zero CAC, role of CAC in diabetics and those on hormone replacement, monitoring plaque progression, frequency of CAC scanning, and use of CAC in combination with treadmill or the so-called ''power of two''.

SECTION IV

This section focuses on the physiologic and metabolic considerations during stress testing and includes 4 chapters.

Chapter 20: Cardiovascular and Pulmonary Responses to Exercise

The chapter discusses in detail the exercise physiology of the cardiovascular system and is a treatise for early career cardiologists to get acquainted with exercise physiology. Several aspects of cardiovascular physiology are explained including impact of exercise on preload, stroke volume, contractility, muscle mass, heart rate and the role of training, age, and gender on cardiovascular physiology. The reader will appreciate a discussion of the impact of training methods, frequency of training, intensity, duration, volume and mode on cardiovascular physiological parameters. The chapter also discusses the effect of exercise on coronary blood flow, coronary resistance, myocardial oxygen demand, tension time index, intramyocardial tension, as well as systolic and diastolic time intervals. This discussion is followed by a treatise on aerobic and anaerobic metabolism, and the effect of hypoxia, ischemia, heat and cold on cardiovascular responses.

Chapter 21: Cardiopulmonary Exercise Testing

The chapter explains the value of cardiopulmonary exercise testing in clinical management. It includes a description of normal exercise physiology, expired gas analysis and interpretation of these measures. The chapter offers great insights into peak VO2 and VCO2 measurements and their utilization in risk prognostication of heart failure patients.

Chapter 22: Heart Rate Response to Exercise

This chapter gives a nice historical perspective of how the formula most commonly used to estimate maximal predicted heart rate was derived in 1971. It then describes the pitfalls of this formula and the derivation of other estimations that have been proposed since and their value. This discussion nicely leads to insightful comments about maximum heart rate in women.

Chapter 23: Metabolic Abnormalities and Drugs

The chapter discusses the effects of metabolic acidosis, alkalosis, hypo and hyperthyroidism, diabetes, estrogens, androgens, nicotine, digitalis, antiarrythmics, anti-anginals, atropine, catecholamines, psychotropics, antihypertensives and alcohol on ECG and ECG interpretation while stress testing. Many pearls are included for clinicians interpreting stress tests.

SECTION V

This sections discusses stress testing in specific populations in 4 chapters.

Chapter 24: Stress Testing in Women

This chapter discusses differences in the presentation and pathophysiology of ischemic heart disease in men and women. It highlights the differential role of multimodality imaging in women vs men.

Chapter 25: Stress Testing of Athletes and Those in High-Risk Occupations

The chapter provides pearls of wisdom on the nuances of stress testing in athletes, firefighters, law enforcement officers, airline pilots as well as astronauts.

Chapter 26: Sports Medicine and Cardiac Rehabilitation for Coronary and Peripheral Artery Disease Patients

The chapter expands on the role of exercise in mitigating cardiovascular risk and the use of exercise testing for rehabilitation prescription among patients with cardiac and peripheral arterial disease. The chapter includes a section on ECG changes that can be seen in athletes which is a useful aide for interpretation of stress tests in these individuals.

Chapter 27: Stress Testing in Children

This chapter is a must read for adult cardiologists who rarely stress children and provides pearls for special considerations for stress testing in children and those with congenital heart disease. The chapter describes how pediatric exercise testing is different from adult stress testing in etiology and in characteristics of cardiovascular response. Included is a very useful section on the exercise recommendations for pediatric patients according to the specific cardiac lesions they have.

SECTION VI

This section discusses the future of stress testing in 2 chapters.

Chapter 28: The Impact of Changing Global Patterns of Atherosclerosis on Stress Testing

The chapter discusses the trends of decreased cardiac mortality in the United States and other industrialized countries and the causes of this decline. As explained in this chapter and throughout the book, this trend alters the sensitivity of exercise testing which has to be taken into account in the interpretation of stress tests.

Chapter 29: Perspectives on the Future of Stress Testing

The editors in the concluding chapter reminisce on how Dr. Ellestad published the first edition of this book in 1975, eight years after Dr. Favaloro performed the first bypass surgery and 2 years before Dr. Gruentzig performed the first angioplasty. This discussion leads to the obvious question of what to expect in the hopefully upcoming 7th edition of the book. They marvel at the advent of what the wondrous technology of advanced imaging has provided to phenotype the heart and conclude by the perfect overarching statement: ''While we have expanded our powers of observation to measure many finer aspects of cardiac structure, function and metabolism, the humanity of being at the side of the treadmill while our whole patients exercise to their individual capacity remains a valuable diagnostic, educational, and bonding opportunity''.

PERSPECTIVE

''Ellestad's Stress Testing: Principles and Practice; 6th Edition'' is a wonderful and comprehensive textbook on the fundamentals and practical aspects of stress testing. It is a useful resource for trainees, practicing providers, and researchers in the field. Although the book benefits from the contributions of 12 specialists other than the editors, the book reads like a single manuscript with many chapters linked together with common themes and no conflicting statements as occasionally occurs in large textbooks. This is a testament to the careful work provided by the editors as you can see their fingerprints even in chapters that they did not co-author. Impressively, the book is rich in colored figures which complement the text. Of special interest are the high-quality ECG tracings, some several decades old but look better than some ECG recordings obtained clinically today, which help to bring to life the teaching points regarding the interpretation of stress tests. One of the editors (GST) told one of us (FGH) that it took 4 years to complete this book. Reading this book from cover to cover, the tremendous effort this feat required is clearly evident in the easy flow of the text, the richness of the material, and the great teaching points included which we are certain will be valuable to many as they were valuable to us.

Finally, we would like to congratulate the authors and the editors on this valuable and unchallenged reference textbook in the field of stress testing. It should be available in all medical libraries and on the shelves of every practicing physician involved with stress tests. We applaud the decision of the editors to rename the book in honor of Dr. Ellestad, a giant of the field who amazingly co-authored many of these chapters but tragically died at the age of 95 in 2016 before the publication of the book that carries his name. Without a doubt, this book will carry the legacy of Dr. Ellestad for the next generation of stress testers.

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