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Phaco Settings Simplified

A Step-by-Step Guide with Tips and Tricks

Dr. Budiman, dr., SpM(K), M.Kes.

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Preface

Phacoemulsification has become the gold standard in modern cataract surgery, yet mastering its technical nuances—particularly machine settings—remains a challenge for many surgeons. While textbooks and training programs often emphasize surgical techniques and anatomy, the practical understanding of phaco settings is frequently learned through trial and error in the operating room. This book was written to bridge that gap by offering a clear, structured, and experience-based guide to phaco settings that are often perceived as complex and intimidating.

Phaco Settings Simplified: A Step-by-Step Guide with Tips and Tricks is designed to demystify the phaco machine by breaking down each parameter into practical, easy-to-understand components. Rather than overwhelming the reader with excessive technical jargon, this book focuses on the why, when, and how of adjusting phaco settings in real surgical scenarios. Each step is explained logically, allowing surgeons to understand not only what settings to use, but also the rationale behind every adjustment.

This book is particularly intended for ophthalmology residents, young cataract surgeons, and practitioners transitioning to advanced phaco techniques. However, experienced surgeons may also find value in the practical tips, troubleshooting strategies, and efficiency-oriented insights presented throughout the chapters. Emphasis is placed on safety, fluidics stability, and adaptability to different cataract densities and intraoperative conditions.

Ultimately, the goal of this book is to build confidence in the operating room. By simplifying phaco settings and presenting them in a step-by-step manner, the reader is encouraged to move beyond rigid presets and develop a personalized, thoughtful approach to phacoemulsification. It is hoped that this guide will serve not only as a learning tool, but also as a reliable companion in daily surgical practice—helping surgeons operate more safely, efficiently, and with greater assurance..

Bandung, January 2026

Author

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Chapter 1. Fundamentals of Phacoemulsification Settings

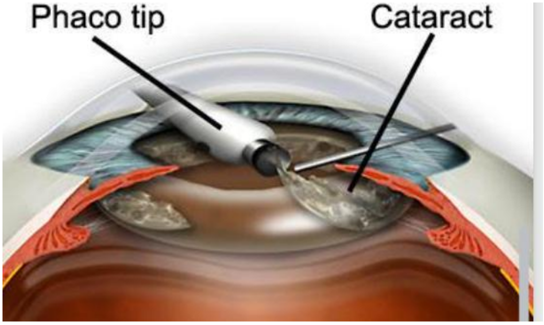
This chapter aims to provide a foundational understanding of phacoemulsification settings by explaining the core technology behind phaco systems and the essential parameters that govern their function. It focuses on clarifying how power, vacuum, aspiration flow rate, and fluidics interact dynamically during surgery, as well as how these settings influence chamber stability and tissue response. Through this foundation, learners are expected to develop the ability to interpret phaco settings logically and recognize their role in maintaining intraoperative control and ocular safety.

A. Overview of Phacoemulsification Technology

Phacoemulsification technology represents a major advancement in cataract surgery, transforming lens extraction from large-incision techniques into a minimally invasive, highly controlled procedure. By utilizing ultrasonic energy to fragment the opacified crystalline lens, phacoemulsification allows simultaneous emulsification and aspiration of lens material through a small corneal incision. This technological evolution has significantly reduced surgical trauma, improved wound stability, shortened recovery time, and enhanced postoperative visual outcomes, making phacoemulsification the current standard of care in modern cataract management.

At its core, phacoemulsification technology integrates three essential functions: energy delivery, fluidics control, and surgeon interface. Ultrasonic energy generated within the handpiece is transmitted to the phaco tip, where rapid oscillations break down lens material into aspiratable fragments. At the same time, balanced irrigation and aspiration maintain anterior chamber depth and intraocular pressure, ensuring a stable surgical environment. The coordination of these systems enables precise manipulation of lens fragments while minimizing stress on surrounding ocular tissues.

The development of phacoemulsification technology has been driven by continuous refinement of energy modulation and fluidics systems. Early phaco machines relied on continuous longitudinal ultrasound, which, while effective, posed risks of excessive heat generation and endothelial damage. Advances in pulse and burst modes, as well as the introduction of torsional ultrasound, have improved cutting efficiency while reducing repulsion and thermal load. These innovations allow surgeons to tailor energy delivery to lens density and surgical phase, optimizing both safety and efficiency (Alió & Piñero, 2017).



Picture 1 : Phaco Emulsification Technique

Equally important is the evolution of fluidics technology within phaco systems. Modern machines employ sophisticated pump mechanisms and pressure-regulating systems to maintain chamber stability even during rapid aspiration or occlusion break. Control over vacuum, aspiration flow rate, and irrigation pressure enables predictable lens followability and reduces the risk of surge and chamber collapse. Understanding these fluidic principles is fundamental, as inappropriate fluidics settings can compromise surgical control regardless of energy efficiency.

Phacoemulsification technology has also benefited from improvements in machine ergonomics and surgeon–machine interaction. Programmable consoles allow preselection of parameters tailored to different cataract grades and surgical techniques, while real-time feedback through foot pedal modulation enables dynamic intraoperative adjustments. This interactive control framework empowers surgeons to respond immediately to changes in tissue behavior, reinforcing precision and adaptability throughout the procedure.

From a clinical standpoint, the widespread adoption of phacoemulsification has demonstrated consistent benefits across diverse patient populations. Numerous studies have shown improved visual acuity outcomes, reduced postoperative inflammation, and lower complication rates compared with conventional extracapsular techniques. Additionally, phacoemulsification has been associated with favorable effects on intraocular pressure dynamics, particularly in patients with coexisting ocular conditions, highlighting its broader therapeutic impact (Baihaqi et al., 2025).

Despite its advantages, phacoemulsification technology requires a thorough understanding of its underlying principles to be used safely and effectively. Overreliance on default machine presets without comprehension of energy–fluidics interaction may increase the risk of complications such as endothelial cell loss, capsular rupture, or thermal injury. Therefore, technological sophistication must be matched by operator knowledge to fully realize the benefits of modern phaco systems.

In summary, phacoemulsification technology is a complex yet highly refined integration of ultrasonic energy delivery, fluidics regulation, and surgeon control mechanisms. Its success lies not only in technological innovation but also in the surgeon's ability to understand, customize, and adapt machine settings to individual surgical scenarios. Mastery of these technological fundamentals forms the foundation for safe, efficient, and reproducible cataract surgery in contemporary ophthalmic practice.

B. Key Parameters: Power, Vacuum, and Aspiration Flow Rate

The success of phacoemulsification surgery is largely determined by the appropriate adjustment of three core machine parameters: ultrasound power, vacuum, and aspiration flow rate. These parameters interact dynamically to control lens fragmentation, fragment capture, and intraocular fluid balance. Inadequate understanding or improper adjustment of any single parameter can disrupt this balance and lead to inefficiency or serious intraoperative complications, including anterior chamber instability, posterior capsule rupture, or endothelial damage. Mastery of these parameters is therefore essential for achieving safe, efficient, and reproducible surgical outcomes.

Rather than functioning independently, power, vacuum, and aspiration flow rate operate as an integrated system. Ultrasound power governs the effectiveness of lens emulsification, vacuum determines the holding force applied to lens fragments, and aspiration flow rate regulates the speed at which fluid and material exit the eye. Optimal phacoemulsification requires tailoring these parameters to the surgical phase, lens density, and ocular anatomy. A systematic yet flexible approach to parameter selection enables surgeons to maintain control while adapting to intraoperative variations.

Power (Ultrasound Energy)

Ultrasound power defines the amount of acoustic energy delivered through the phaco tip to fragment the crystalline lens. This energy can be applied in various modes, including continuous, pulse, burst, torsional, or combined modalities, each producing distinct mechanical effects on lens material. The primary objective of power modulation is to achieve effective nucleus fragmentation while minimizing collateral damage to surrounding ocular tissues.

Excessive ultrasound energy has been associated with thermal and mechanical injury, particularly to the corneal endothelium and incision site. Heat generation at the phaco tip can occur when energy delivery exceeds irrigation cooling capacity, especially during prolonged occlusion or inadequate fluid flow. Modern cataract surgery therefore emphasizes energy efficiency, aiming to reduce cumulative dissipated energy without compromising emulsification performance (Alió & Piñero, 2017).

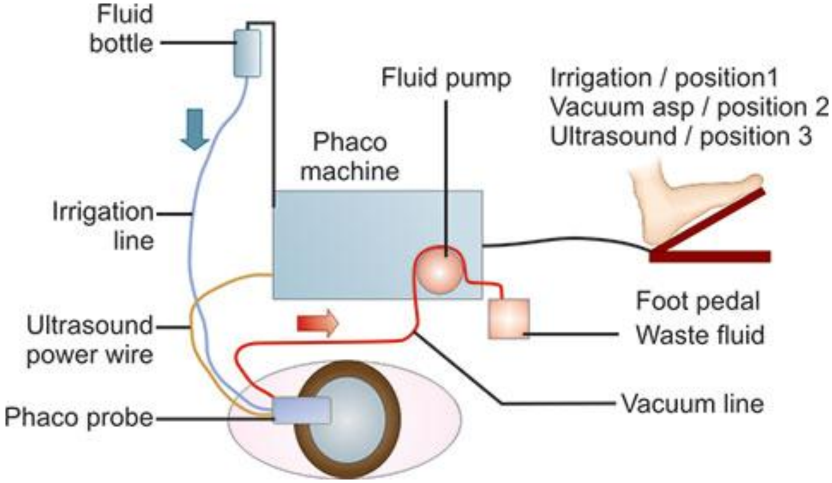
Power requirements vary significantly according to cataract density. Soft cataracts often require minimal ultrasound energy and may be managed primarily through aspiration-based techniques. In contrast, dense or brunescent nuclei demand higher power levels, typically delivered in modulated bursts to reduce continuous heat exposure. Pulse and burst modes allow intermittent energy delivery, improving control and reducing endothelial stress during critical phases such as chopping and fragment emulsification.

Advances in torsional and hybrid ultrasound technologies have further refined power utilization. Lateral oscillatory movements increase cutting efficiency while reducing repulsion of lens fragments, allowing lower effective power settings. When properly applied, ultrasound power becomes a precision tool rather than a source of risk, contributing to improved surgical safety and visual outcomes.

Vacuum

Vacuum controls the negative pressure that draws lens material toward and holds it at the phaco tip. Its primary function is to stabilize nuclear fragments during emulsification and facilitate effective chopping techniques. Adequate vacuum enhances surgical efficiency by allowing secure engagement of the nucleus, thereby reducing reliance on high ultrasound energy.

Lower vacuum settings are typically preferred during early surgical stages or in soft cataracts, where gentle control is prioritized. Higher vacuum levels are particularly advantageous during phaco chop techniques, as they provide firm fragment fixation before mechanical division. However, elevated vacuum increases the risk of post-occlusion surge, especially if not balanced with appropriate flow rate and fluidics design.



Picture 2 : How the Phacoemulsification Machine Works.

Surge represents one of the most significant vacuum-related complications. Sudden occlusion break can result in rapid fluid outflow, leading to anterior chamber collapse and increased risk of posterior capsule damage. The likelihood and severity of surge are influenced by vacuum level, tubing compliance, pump type, and irrigation pressure (Morgan & Dart, 2020; Spandau & Scharioth, 2022).

Contemporary phaco machines allow linear vacuum control through the foot pedal, enabling surgeons to modulate vacuum in real time. This

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About The Author

Dr. dr. Budiman, Sp.M(K), M.Kes., is the author of several books on cataract surgery in accordance with his subspecialty expertise, which he has pursued for many years. He has also contributed to a number of cataract-related books published by the Indonesian Society of Cataract and Refractive Surgery (INASCRS). The author is an ophthalmologist with subspecialty training in Cataract and Refractive Surgery at the Department of Ophthalmology, Faculty of Medicine, Universitas Padjadjaran (Unpad), and the National Eye Center, Cicendo Eye Hospital, Bandung.

He has consistently focused on cataract and refractive surgery since completing his ophthalmology specialist training and began his career in 1997 as a teaching staff member at the Department of Ophthalmology, Faculty of Medicine, Unpad, as well as a functional staff member at the National Eye Center, Cicendo Eye Hospital, Bandung, eventually attaining the rank of senior consultant ophthalmologist. He completed a master's degree in basic medical sciences in 2003 and earned his doctoral degree from Universitas Padjadjaran in 2015, with a dissertation in the field of cataract and myopia genetics, graduating cum laude.

Currently, he is actively involved as a principal author in various cataract-related studies published in both national and international journals. In addition, he frequently serves as a speaker and surgical instructor in phacoemulsification cataract surgery and LASIK refractive surgery at numerous seminars and symposia.

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A Step-by-Step Guide with Tips and Tricks

TThis textbook is designed as a concise yet comprehensive guide for ophthalmology residents and cataract surgeons who wish to master the art of optimizing phacoemulsification machine settings. Understanding how to balance energy, vacuum, and fluidics is crucial to achieve effective lens removal while preserving corneal endothelium and minimizing complications. Presented in a practical, step-by-step format enriched with clinical pearls, this book highlights essential tips, troubleshooting strategies, and real-world applications for various cataract grades and surgical techniques. Written with clarity and focus, Phaco Settings Simplified bridges the gap between theory and surgical practice, serving as both a quick reference and a training companion in modern cataract surgery.

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