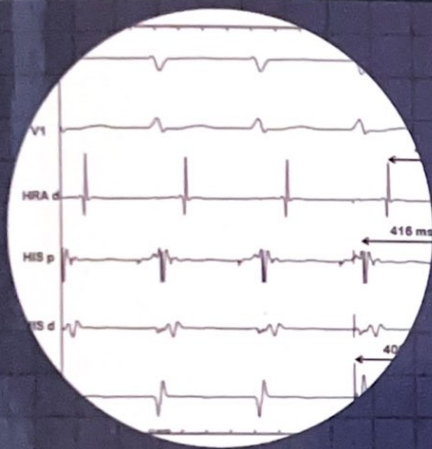


ECG TO ABLATION

A Comprehensive Guide
to Cardiac Electrophysiology



Ashutosh Kumar

About The Author

Dr. Ashutosh Kumar is a highly esteemed cardiologist specializing in Interventional and Electrophysiology procedures. With over 18 years of experience, he has established himself as an expert in his field.

Dr. Kumar obtained his MBBS degree from Sri Krishna Medical College in 2002, followed by an MD in General Medicine from Esteemed Banaras Hindu University in 2006. He then pursued further specialization in Cardiology at the renowned Institute of Postgraduate Medical Education and Research in Kolkata in 2009

Throughout his career, Dr. Kumar has actively sought opportunities for professional growth. He served as a Assistant professor at GSL Medical College and Narayana Medical College from 2009 to 2016. Additionally, he has gained valuable international experience through fellowships and observerships in Germany, Malaysia, the USA, and Taiwan.

Dr. Kumar is among the few cardiac electrophysiologists in India who hold both CCDS, and CEPS-AC certification from the IBHRE, USA since 2017. His expertise is further recognized by his fellowship honors from esteemed institutions such as FACC, FESC, FHRS, and FSCAI.

Previously, Dr. Kumar held the position of Additional Director in Cardiology at Care Hospital, Hyderabad, from 2016 to 2020. Currently, he serves as the Clinical Director of Cardiac Electrophysiology at Care Group Hospital Hyderabad and is an Associate Professor at Kamineni Academy of Medical Sciences and Research in Hyderabad, India. He is also the founder of the Heartbeat Foundation, a charitable organization dedicated to addressing heart rhythm disorders.

For any inquiries or to contact Dr. Kumar, please feel free to reach out to him via email or WhatsApp.

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DR. ASHUTOSH KUMAR

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A COMPREHENSIVE GUIDE
TO CARDIAC ELECTROPHYSIOLOGY

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PREFACE

I am immensely proud and delighted to present this book on electrophysiology, which is the result of my dedicated efforts to provide essential tools and techniques to fellows in training. The field of cardiac electrophysiology already has numerous renowned books that serve as indispensable resources for individuals pursuing a career in this specialized field. These books offer a wealth of information and knowledge necessary for a comprehensive understanding of electrophysiology. However, there is a specific need for a concise yet comprehensive guide tailored specifically to fellows during their training in the electrophysiology laboratory.

With this objective in mind, I have endeavored to bridge that gap by creating this book, which aims to equip fellows with the necessary information for their crucial learning period. The book covers various aspects of electrophysiology, starting from the basics such as ECG interpretation, hardware selection, fluoroscopy techniques, and anatomy. Section A provides an extensive exploration of these fundamental topics, serving as a solid foundation before delving into the core concepts of electrophysiology covered in Section B.

One distinct feature of this book is the inclusion of approximately 200 questions at the end of Section B. These questions have been meticulously designed to facilitate revision and reinforcement of the key concepts discussed throughout the book. Moreover, these questions also serve as valuable preparation for the IBHRE-CEPS exams, as some of them have been previously asked in those examinations.

I firmly believe that this book will simplify the complex field of electrophysiology, particularly during the early stages of one's career. By providing a clear and concise resource, my hope is that this book will serve as a valuable companion for fellows in their pursuit of knowledge and proficiency in cardiac electrophysiology.

I would like to express my eternal gratitude to my parents, Sri Ganesh Thakur & Smt Manna Devi. Their unconditional love, unwavering support, and constant encouragement have been the foundation of my life. They have guided me and instilled in me the values of perseverance and determination that have driven me forward in my pursuit of knowledge and excellence.

Throughout the journey of writing this book, I have received immense support from various individuals who have played integral roles in its completion. First and foremost, I express my heartfelt gratitude to my wife, Dr G Bhawani, who has patiently supported me through the time and sacrifices that accompanied the writing process. Her unwavering encouragement and belief in me have been my pillars of strength.

I am indebted to my daughter, Annanya, whose constant reminders and genuine interest in the progress of the book served as a motivating force. Her enthusiasm and faith in this endeavor kept me inspired even during challenging times.

To my son, Kartikeya, whose expectation that I write a book pushed me forward, I extend my deepest appreciation. His innocent belief in my ability urged me to reach higher and strive for excellence.

I would also like to express my heartfelt gratitude to my elder brother, Dr. Srinivas Narayan, Mr. Goru Bhaskar Rao, and Mr. Koka Jaganadha Rao, whose unwavering belief in me and constant encouragement have been instrumental in my journey. Their support and motivation have been the driving force behind my pursuit of higher goals and aspirations.

I must acknowledge the invaluable contributions of my mentor, Dr. Omar Razali, who played a significant role in clarifying complex concepts during my training. His guidance and expertise were instrumental in shaping my understanding of electrophysiology.

I am also grateful to Dr. Surrender Kaur Khale, whose commitment to teaching and willingness to share her knowledge strengthened my fundamentals in electrophysiology. Her dedication has been pivotal in my growth.

Furthermore, I would like to extend my gratitude to Dr. Zulkeflee Muhammad and Dr. Koh Koh Wee for their support and assistance throughout my training period. Their guidance and mentorship played a crucial role in honing my skills and expanding my understanding.

I extend my deepest appreciation to my esteemed teachers in cardiology, Dr. Kamlesh Tiwari, Dr. Mantosh Panja, Dr. Amal Kumar Banerjee, Dr. Achyut Sarkar, and Dr. Biswakesh Majumdar. Their wisdom, expertise, and mentorship have been invaluable in shaping my understanding of cardiology and nurturing my passion for this field. They believed in my potential, provided guidance during challenging times, and inspired me to push my boundaries to achieve greater heights.

Lastly, I wish to express my deep appreciation to Dr. Vineet Gera and Mr. Santosh Singh Bisht from Gurukool Publication for providing the necessary resources and support for the publication of this book. Without their assistance and belief in the significance of this work, the realization of this book would not have been possible.

In conclusion, I hope this book serves as a valuable resource for cardiology fellows in training and anyone interested in the field of electrophysiology.

Best regards,

Dr Ashutosh Kumar

MD DM FACC FHRS

Hyderabad

21 July 2023

DEDICATED TO

Dedicated To the Unknown Bodies, the Believing Patients, and the Teachers & Parents

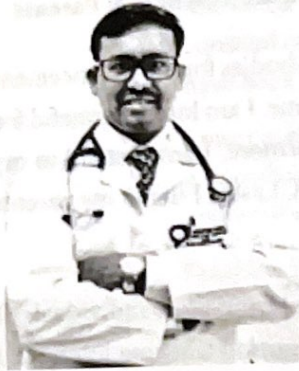
This book is a tribute to the unsung heroes who have donated their bodies for the advancement of medical science and to the patients who have put their trust in me. I am forever grateful for their generous contributions to my journey in medicine. Furthermore, I am grateful to my teachers, whose wisdom and passion have guided me on this path. Lastly, I thank my parents for their unwavering love and support.

This book is a culmination of the invaluable lessons I have learned from these individuals. It is a celebration of the medical community, where learning, healing, and teaching intersect. I hope this book will serve as a source of knowledge, inspiration, and comfort to all who read it, and honour the legacy of those who have shaped my path in medicine.

With heartfelt gratitude and respect,

Dr Ashutosh Kumar MD DM FACC FHRS

ABOUT THE AUTHOR



Dr. Ashutosh Kumar is an accomplished senior cardiologist with an impressive 18-year career in the field. He obtained his MBBS degree from Sri Krishna Medical College in 2002 and pursued further education at Banaras Hindu University, earning an MD in General Medicine in 2006. Dr. Kumar's passion for cardiology led him to specialize in the field, completing a DM from the Institute of Postgraduate Medical Education and Research in 2009.

Throughout his career, Dr. Kumar has held significant positions in both academia and clinical practice. He served as an Assistant Professor in the Department of Cardiology at GSL Medical College from 2009 to 2014 and at Narayana Medical College from 2014 to 2016. He has also gained valuable international experience through a fellowship at the National Heart Institute in Kuala Lumpur, Malaysia, and observerships at renowned institutions in Germany, the USA, and Taiwan.

Dr. Kumar's expertise is widely recognized, as evidenced by his prestigious certifications and memberships. He holds the International Board of Heart Rhythm Examiners (IBHRE, USA) certification for cardiac device specialists (CCDS) and the Certified Electrophysiology Specialist in Adult Cardiology (CEPS-AC) designation. He has received honors and recognition from esteemed organizations such as the American College of Cardiology, the European Society of Cardiology, the Heart Rhythm Society, and the Society of Cardiology Angiology and Intervention.

Currently, Dr. Kumar serves as the Clinical Director of Cardiac Electrophysiology at Care Group Hospital and is an Associate Professor of Cardiology at Kamineni Academy of Medical Sciences and Research in Hyderabad, India. Additionally, he is the visionary behind the Heartbeat Foundation-Hyderabad, a charitable trust dedicated to raising awareness about heart rhythm disorders.

Dr. Kumar has extensive expertise in performing various cardiac procedures, including over 10,000 cardiac angiographies and angioplasties, more than 3000 pacemaker and implantable cardiac device placements, and over 1000 cardiac radio-frequency ablations. He is highly skilled in 3D mapping of complex cardiac arrhythmias and ablations.

In addition to his clinical work, Dr. Kumar has made significant contributions to medical literature through research, publications, and active participation in professional societies. He has authored over 35 publications and serves as an editorial board member for reputable journals. To contact Dr. Ashutosh Kumar or learn more about his work, please feel free to reach out to him via email at drashutoshvani@gmail.com or through WhatsApp at +91 9963299122.

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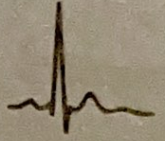
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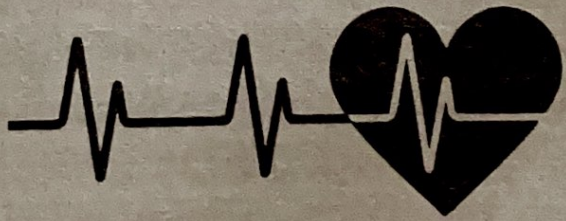
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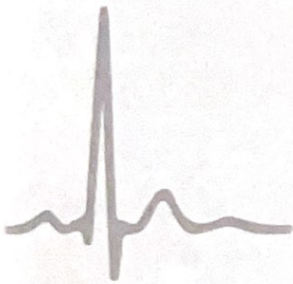
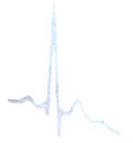
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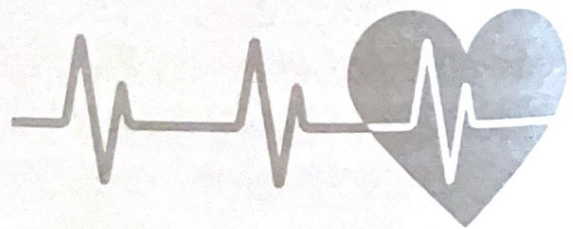


SECTION-A





CHAPTER 1
ECG TO EGM



1.1 HISTORY

The year 2022 marks 55 years of electrophysiology (EP). The progress made during these decades has been spectacular, especially in the light of history. It took centuries to understand the structures and functions which form the foundations of current clinical electrophysiology. We have come a long way. With the recording of the first PQRST complex in a human in 1901 by Willem Einthoven with the 600-pound machine and five operators the patient had to put two hands and one foot in a bucket with an electrolyte solution to obtain a 3-lead electrocardiogram (ECG).

Invasive clinical EP is based on the same technique devised by Werner Forssmann for the heart catheter technique. In 1967, Dirk Durrer and Hein Wellens demonstrated the initiation and termination of arrhythmias by programmed electrical stimulation (PES) in a patient with Wolff-Parkinson-White (WPW) syndrome in Amsterdam. At the same time in Philippe Coumel reported similar findings in a patient with atrioventricular junctional tachycardia in France. EP was first used to induce ventricular tachycardias (VT) and elucidate WPW mechanisms. In 1968, Cobb reported that surgical interruption of the bundle of Kent using epicardial mapping could cure WPW syndrome. Benjamin Scherlag was able to produce consistent His Bundle recordings in humans using a catheter in 1969. Giraud was the first to describe intracardiac leads in 1960 and demonstrated His bundle recording in ASD patients. Combining interpretations of the 12 lead ECG during arrhythmias and PES data brought new insights and work of Henry Marriott as well as by Wellens, led to a deeper understanding of the origin of wide QRS tachycardias. In 1968, Cobb and Sealy et al performed the first surgical interruption in a WPW patient. Gerard Guiraudon, Guy Fontaine (who is also credited for the discovery of ARVD), as well as Mark Josephson, made surgery for VT possible. Mark Josephson was one of the pioneers in catheter-based treatments of cardiac arrhythmias. He was among the first to find the pathogenesis of VT after MI, and developed methods for mapping arrhythmias, which could later be used to ablate them. The first catheter-induced AV block was found by serendipity in 1981 when Rolando Gonzales and Melvin Scheinman reported that

a defibrillating electrode accidentally came into contact with an electrode catheter in the His-bundle. It opens the new arena of catheter ablation when direct current is used as ablation energy. Later on, larger series of ablation using direct current were performed by Scheinman and Gallagher in 1982. The first successful radiofrequency (RF) ablation of an accessory pathway was carried out in Munster, Germany in 1987 by Martin Borggrefe et al and in the 1990s, direct current (DC) ablation was replaced by radiofrequency energy. Later cryoablation also became a possibility.

1.2. INTRODUCTION

Electrophysiology is the science of understanding of conduction system and its property and how it is modified in diseases. It starts with an understanding of various types of channel involved in the action potential of cells and how this action potential is modified in diseases. The biggest hurdle come for a fellow when he enters EP lab when it became difficult to utilize the theoretical knowledge in practical application while understanding the ECG and EGM in EP lab. The reading of ECG and EGM when on the LIVE screen and interpreting the signal is a daunting job. This chapter will help by providing the foundation to understand and utilize the practically important point to a fellow in the initial days in EP lab and approach to the new language of cardiology (EP vocabulary).

Importance of ECG and its electrophysiological interpretations: The essential part of interventional EP is the best understanding of the ECG. The way the interventional cardiologist sees the surface ECG and interventional EP see is quite different. The interventional EP sees the ECG as a ladder diagram and makes the differential diagnosis accordingly. Hence, it is better to have good homework on surface ECG; most of the information is available before entering the EP Lab. A good electrophysiologist needs less catheter and less time to deduce the diagnosis and hence the ablation of arrhythmia. It is my personal take that interventional EP should never overlook the importance of surface ECG and ECHO anytime as it saves time during interventional EP. The importance of history and previous EP details is very vital. The more you do the homework prior to the EP lab lesser will be the surprises on the table and lesser will be time from diagnosis to

signal atrial or ventricle with reference to time at that location. Any stable single morphology atrial or ventricular arrhythmia has a *fixed substrate* on which the activation pattern happens. The catheter placed in different locations (RA, RV, HIS, CS) provides the same activation pattern in reference to time and location.

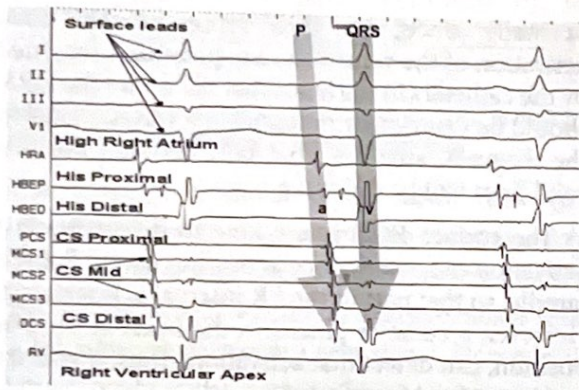


Figure-1.1: start from surface ECG to EGM

RULE 2: Fix your EGM color coding and order

It is essential to fix your colour coding of EGM & ECG. It is essential because if we want to have a *quick understanding*, we must have a fixed screen pattern template while reading. The colour coding and position of leads will help us initially where to focus, and what to focus for. It saves time and is very vital in the initial days of EP. At the later time with experience, it is not that important as our reflexes of focus get matured where to look for and what to look for. I have heard about some lab that has fixed their template for decades.

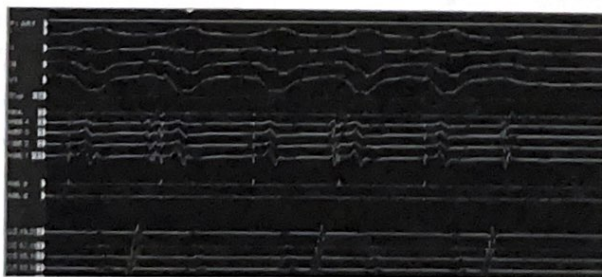


Figure - 1.2: fix the colour and order of display keep the colour of catheter fixed CS-green, His -yellow, RV magenta, Ablation -white

RULE 3: Start making sense of all the signals in reference to surface ECG

Pattern recognition is one of the easiest and most established methods to identify arrhythmia. When we read the EGM, it becomes essential to completely verify the surface ECG information with EGM data. One piece of information complements other information when it comes to interpreting the EGM. Hence during reading the EGM it is essential that *every signal should be explained*. It became very important when we start struggling in pathway ablation where it will provide whether we are dealing with a muscular band of tissue connecting CS to ventricle where we must go epicardial vs bundle of Kent connecting atrium to ventricle where endocardial ablation is mostly sufficed. The pattern of atrial, CS and extra potential helps a lot in understanding. It is worth giving time when you are facing failed ablation.

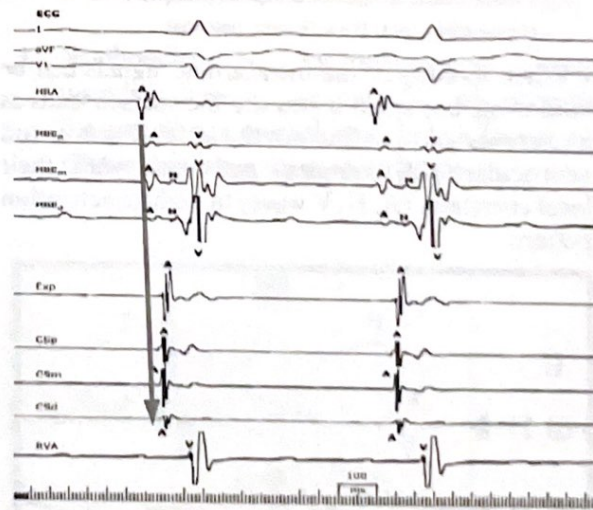


Fig - 1.3: During Sinus rhythm (vertical axis)RA-HIS-V

SECTION 1.4 INTRACARDIAC ELECTROGRAM TERMINOLOGY:

The surface leads are used as a reference, because they represent the entire activation of the heart. Thus they are a good reference to determine timing such as the onset of atrial or ventricular activation in relation to the intracardiac catheters. To do so you just draw a line or place the calipers at the

ECCG TO ABLATION

irrigation ablation catheter

Q9. With irrigation ablation catheter all the following is correct except

- a) Maximum temperature is at electrode -tissue interface(endocardium)
- b) Maximum temperature is below electrode -tissue interface(endocardium)
- c) Open irrigation systems has lower incidence of both thrombus formation and steam pops than seen with closed-loop irrigated RF ablation
- d) Active electrode cooling by irrigation allows sustained RF power best for low flow area like CS

Q11. What is the best position of irrigation catheter for maximal heat transfer while ablation

- a) Parallel
- b) Perpendicular
- c) 45 degree to surface
- d) Horizontal

Q12. All the following is correct regarding irrigation catheter except

- a) Closed loop irrigation has more risk of thrombus formation vs open loop irrigation
- b) Lesion diameter does not increase with high irrigation flow rates in open-loop irrigation
- c) Deeper lesion created with high catheter contact pressure
- d) Lowering the irrigation flow rate from the standard rate of 17 ml/min to 2 ml/min led to shallow and superficial lesions
- e) Temperature-controlled mode is the preferred mode while using the irrigation tip catheter

Q13. All of the following is correct regarding temperature setting while ablation except

- a) RF ablation is most often performed in the temperature control mode(TCM) except in irrigation mode where it is PCM(power controlled mode)
- b) TCM was associated with a threefold reduction

in the incidence of developing a coagulum

- c) In non-irrigation mode, thrombus occurred at interface temperature $\geq 80^{\circ}\text{C}$.
- d) In irrigation mode power is adjusted to always keep the electrode tip temperature above 40°C for adequate power delivery.

Q14. All are manifestation of overheating

- a) Perforation
- b) Cardiac rupture
- c) Clot formation
- d) Decrease contact force

Q15. If RF duration and power were kept constant, the following will increase proportionately with increasing CF

- a) Lesion depth
- b) Lesion diameter
- c) Lesion volume
- d) All

Q16. What is the temperature needed for cryomapping

- a) 0°C
- b) -20°C
- c) -30°C
- d) -70°C

Q17. Which gas is used for cryoablation

- a) NO
- b) N_2O
- c) NO_2
- d) NO_3

Q18. Ablation index incorporates parameter all the parameter except

- a) Contact Force
- b) Power
- c) Duration
- d) Temperature

Q19. Minimum contact forces for good contact in the RV, LV, and epicardial mapping respectively

About The Author

Dr. Ashutosh Kumar is a highly esteemed cardiologist specializing in Interventional and Electrophysiology procedures. With over 18 years of experience, he has established himself as an expert in his field.

Dr. Kumar obtained his MBBS degree from Sri Krishna Medical College in 2002, followed by an MD in General Medicine from Esteemed Banaras Hindu University in 2006. He then pursued further specialization in Cardiology at the renowned Institute of Postgraduate Medical Education and Research in Kolkata in 2009

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For any inquiries or to contact Dr. Kumar, please feel free to reach out to him via email or WhatsApp.

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