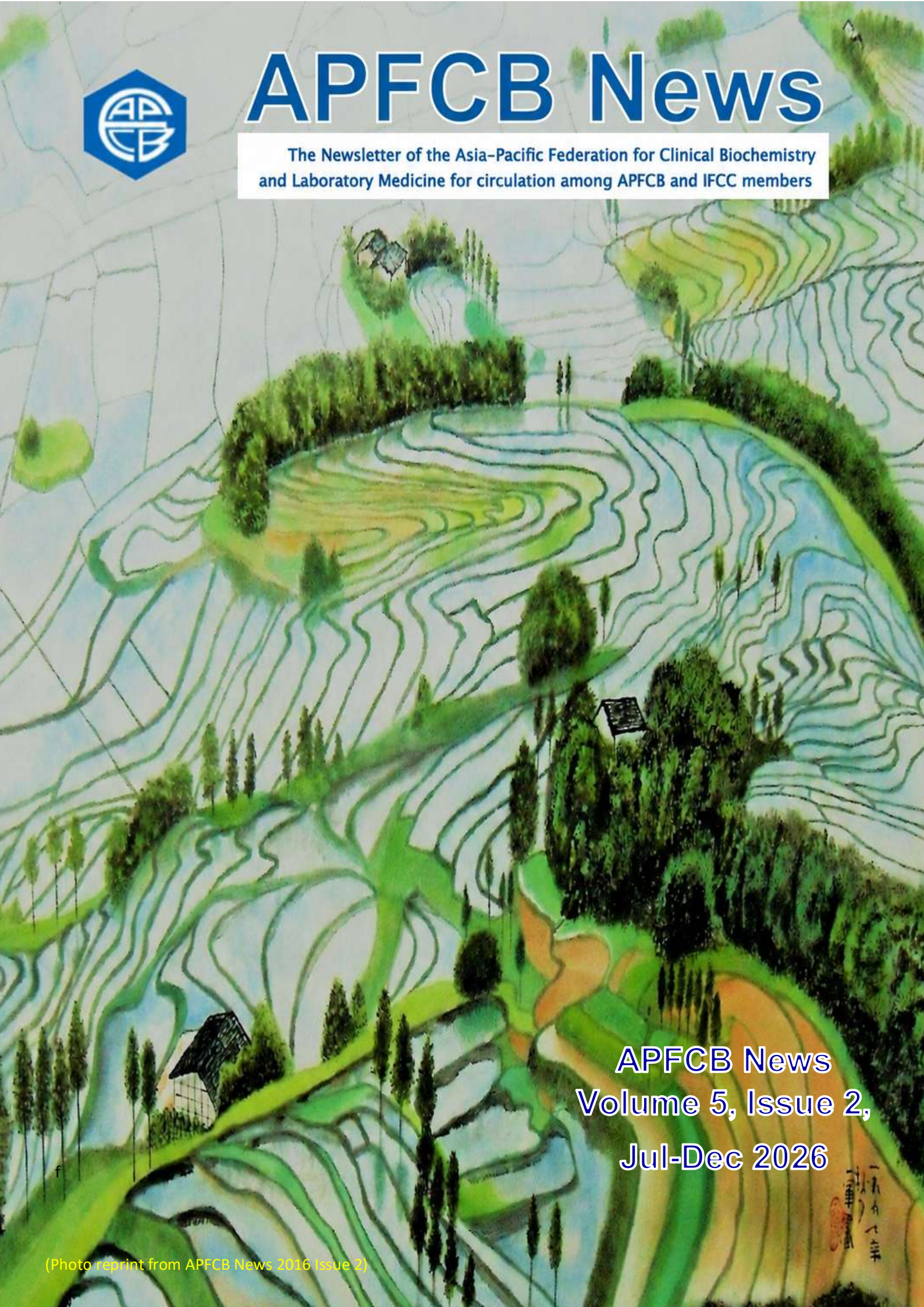
APFCB News

The Newsletter of the Asia-Pacific Federation for Clinical Biochemistry and Laboratory Medicine for circulation among APFCB and IFCC members



APFCB News
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Publication Team, 2026 Issue 2

Editors

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Executive Board

Chairman of Committees

Submission

The APFCB News welcomes suitable contributions for publication. These should be sent electronically to the Chief Editor. Statements of opinions are those of the contributors and are not to be construed as official statements, evaluations or endorsements by the APFCB or its official bodies.

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Cover page: "Beautiful Terraced Ricefields in China". Contributed by Tan It Koon

Founding and Past President APFCB

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From the desk of APFCB President

President, APFCB
Dr Tony Badrick

Dear APFCB members

Welcome to the second edition of the APFCB Newsletter for 2026. The world is full of uncertainty due to natural disasters and geopolitical conflicts that are impacting the lives of billions of people, especially in the Asia-Pacific region. We pray for those people directly impacted by floods, conflict and food shortages.

As usual, this edition features many stories from our member organisations about their work to improve the training and well-being of laboratory personnel across different countries. Our vital work within the healthcare system continues.

But there is an extra focus on laboratory sustainability. The APFCB sees this as a critical investment in the future lives of all our families and us. The Laboratory Management Committee has a special focus on sustainability and uses one of its webinar series to educate on ways to mitigate this impact.

In this edition of the Newsletter is an expert panel QNA on laboratory sustainability. As scientists, it is important that we question any 'facts' that are presented to us. But when that evidence is overwhelmingly supported by observation and sound science, we are negligent if we don't accept it and advocate for change. Laboratories should be the beacons in healthcare for reuse, recycling, and reduced waste.

The Newsletter is a major initiative of the Communication and Publications Committee. I would like to thank Dr Pradeep Kumar Dabla and his team for all their effort.

Best Wishes
President, APFCB
Dr Tony Badrick

From The Desk of Chief Editor, APFCB News

Director Prof. Pradeep Kumar Dabla Chief Editor, APFCB News

Dear Esteemed Colleagues,

The APFCB Communication and Publications Committee (C-CP) continues to strengthen its commitment to serving the laboratory community by providing a platform that informs, educates, and connects professionals across the Asia-Pacific region. Over the past year, through APFCB News, educational features, expert opinion articles, digital engagement, and close collaboration with our member societies and corporate members, we have worked to promote knowledge sharing, professional development, and the exchange of best laboratory practices. None of these achievements would have been possible without the enthusiasm of our contributors, reviewers, editorial board members, and dedicated readers.

As laboratory medicine continues to advance through automation, digital technologies, artificial intelligence, and precision diagnostics, “Medical Lab Sustainability” has emerged as a defining priority. Today's laboratories must deliver high-quality, patient-centred services while responsibly managing resources while reducing environmental impact, and ensuring financial and workforce resilience. Sustainability is no longer limited to reducing waste or conserving energy; it encompasses smarter test utilization, greener laboratory operations, digital transformation, capable of meeting future healthcare needs.

Recognizing this important transition, the APFCB C-CP is pleased to present expert perspectives from distinguished leaders who share practical insights and innovative approaches to building sustainable medical laboratories. We hope these contributions will stimulate discussion, inspire meaningful change, and encourage laboratories to adopt sustainable practices without compromising quality, safety, or patient care.

Together, let us continue building a future where excellence in laboratory medicine and sustainability advance hand in hand.

Sincerely,

Prof. (Dr.) Pradeep Kumar Dabla
Chair, APFCB Communication & Publications Committee (C-CP)

Happy Reading!!
Team APFCB C-CP

APFCB Communication and Publications Committee (C-CP)

Director Prof. Pradeep Kumar Dabla
Chief Editor, APFCB News

Members of the APFCB C-CP for the Term:

- **Chair:** Dr. Pradeep Kumar Dabla
- **Web Editor:** Dr. Deepak Parchwani
- **Social Media Coordinator:** Dr. Vivek Pant

Members:

Dr. Ryunosuke Ohkawa

Dr.Jitender Sharma

Dr.Sarah Jane L. Datay-Lim

Dr. Deepak Parchwani

Dr. Vivek Pant

Dr. Mayank Upadhyay
(Corporate - QuidelOrtho)

1. Introduction

Communication & Publications Committee (C-CP)

During the current term, the Communication & Publications Committee (C-CP) underwent a reconstitution with the induction of Dr. Jitender Sharma and Dr. Sarah Jane L. Datay-Lim as new committee members. They succeed Dr. Alireza Lotfi Kian and Dr. Mingma Lhamu Sherpa, who completed their distinguished tenure on the committee from 2023–2026. The C-CP on the behalf of APFCB gratefully acknowledges the invaluable contributions and dedicated service of the outgoing members and extends a warm welcome to the new members, whose expertise and commitment will further strengthen the committee's vision and activities.

The Communication & Publications Committee serves as the strategic voice of the Asia-Pacific Federation for Clinical Biochemistry and Laboratory Medicine, leading the federation's communication, publication, digital engagement, and educational outreach initiatives. As a standing committee of the APFCB Executive Board, the C-CP is dedicated to enhancing the federation's visibility, fostering scientific exchange, and strengthening collaboration among laboratory medicine professionals throughout the Asia-Pacific region.

Driven by innovation and excellence, the committee develops and oversees communication strategies that align with APFCB's vision and long-term objectives. It manages the federation's digital ecosystem, ensuring a consistent, dynamic, and impactful online presence while supporting the dissemination of high-quality scientific knowledge and educational resources.

A key responsibility of the C-CP is the publication of the APFCB News, which showcases scientific achievements, educational activities, committee initiatives, and member society updates. Working closely with APFCB member associations, international organizations, and corporate partners, the committee facilitates the timely exchange of information, promotes collaborative initiatives, and expands access to valuable educational content for professionals across the laboratory medicine community.

Over the past year, the C-CP has significantly strengthened APFCB's digital footprint through its official website, APFCB news, social media platforms, and innovative online educational programs. By leveraging modern communication technologies and digital engagement strategies, the committee has successfully amplified the federation's activities across the Asia-Pacific region while extending its reach to the global laboratory medicine community through collaboration with the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). These efforts have reinforced APFCB's reputation as a leading regional scientific organization committed to advancing laboratory medicine, promoting professional development, and ultimately improving patient care.

2. Major Activities & Achievements

2.1 APFCB Webcast & e-Learning Programme

The year 2026 represented another landmark in the evolution of the APFCB Webcast & e-Learning Programme, reaffirming the federation's commitment to advancing continuous professional education and facilitating the dissemination of cutting-edge scientific knowledge across the Asia-Pacific region. Building upon the remarkable success and growing international recognition of the programme, the Communication & Publications Committee curated a series of high-impact webinars featuring globally acclaimed experts, addressing contemporary challenges and emerging developments in laboratory medicine.

- Among the flagship educational events was the webinar on "EQA and Quality Improvement Practices in Resource-Limited Settings," moderated by Dr. Sarah Jane L. Datay-Lim, with distinguished presentations by Prof. (Dr.) Paulo Enrico P. Belen and Prof. (Dr.) Rodelio D. Lim. The session offered valuable insights into practical quality management strategies tailored to resource-constrained healthcare environments, highlighting sustainable approaches to improving laboratory performance.
- In alignment with the overarching theme of this year's publication, the committee also organized an insightful webinar on "Sustainable Laboratory Medicine." Moderated by Dr. Tony Badrick, the session featured Dr. Lia Partakusuma and Dr. Sohini Sengupta, who explored innovative strategies for developing environmentally responsible, resilient, and future-ready laboratory services while maintaining the highest standards of quality and patient care.
- Continuing its commitment to delivering education at the forefront of laboratory medicine, APFCB successfully conducted its webinar on 30 July 2026, titled “Precision Cardiology: Integrating Evidence-Based Therapy and Laboratory Excellence.” The programme was moderated by Prof. (Dr.) Pradeep Kumar Dabla and featured expert presentations by Prof. (Dr.) Nafija Serdarevic on “Interference in Cardiac Marker Assays: Pitfalls, Detection, and Clinical Impact” and Prof. (Dr.) Vimal Mehta on “Residual Cardiovascular Risk: Is Hypertriglyceridemia the Missing Piece?” The webinar highlighted the indispensable role of laboratory medicine in advancing precision cardiovascular care, ensuring analytical excellence, and supporting informed clinical decision-making.

The APFCB Webcast & e-Learning Programme continues to witness unprecedented engagement from the global laboratory medicine community. Across all educational sessions, participation has consistently exceeded expectations, accompanied by overwhelmingly positive feedback from delegates. Several webinars attracted more than 4,000 registrations, representing participants from numerous countries across the Asia-Pacific region and beyond.

This remarkable level of engagement underscores the programme's growing international reputation as a premier platform for scientific exchange, professional development, and collaborative learning, further strengthening APFCB's leadership in laboratory medicine education.

2.2 Publication Activities

The Communication & Publications Committee continued to strengthen APFCB's scientific communication by curating, editing, and publishing high-quality content through the federation's official APFCB News. Serving as a dynamic platform for scientific exchange and professional engagement, the publication showcases contemporary developments, educational resources, and activities from across the Asia-Pacific laboratory medicine community.

The January 2026 issue of the APFCB e-News was successfully published, featuring a rich collection of expert perspectives, state-of-the-art review articles, educational case discussions, interviews with emerging scientists, reports from member societies, and updates from APFCB committees and federation initiatives.

The July 2026 issue further expands the scope and impact of the publication. The current edition presents a comprehensive compilation of invited expert reviews, opinion articles, educational case studies, interviews with rising leaders in laboratory medicine, highlights of APFCB educational programmes, reports from national societies, committee activities, and updates from member federations. In addition, the issue places a special emphasis on Sustainable Laboratory Medicine, reflecting APFCB's commitment to promoting environmentally responsible laboratory practices while fostering innovation, scientific excellence, and regional collaboration.

2.3 Research and Quality Improvement Initiatives

Building upon the success of the two APFCB collaborative publications featured in the February issue of eJIFCC(https://pmc.ncbi.nlm.nih.gov/articles/PMC12882077/ and https://pubmed.ncbi.nlm.nih.gov/41659289/), the Communication & Publications Committee expanded its scholarly activities by initiating a federation-wide research survey aimed at addressing contemporary challenges in laboratory quality management.

The committee launched a cross-sectional survey **entitled "Assessing the Assessors: A Cross-Sectional Survey of ISO 15189 Implementation Challenges and Improvement Strategies in Asia-Pacific Clinical Laboratories."** The survey seeks to capture the experiences, perspectives, and practical challenges encountered by ISO 15189 assessors across the Asia-Pacific region. By identifying common barriers, best practices, and opportunities for improvement, the initiative aims to generate evidence that will inform future APFCB educational programmes, quality improvement strategies, and policy development. The findings are expected to contribute meaningfully to strengthening laboratory accreditation practices and promoting excellence in quality management throughout the region.

2.4 Research and Quality Improvement Initiatives

The APFCB official website continued to evolve as the federation's principal digital gateway for scientific communication, member engagement, and dissemination of educational resources. Throughout 2026, the Communication & Publications Committee undertook continuous enhancements to ensure that the website remained contemporary, informative, and aligned with the evolving needs of the laboratory medicine community. Significant improvements were implemented to enhance the overall user experience, including a more intuitive interface, streamlined navigation, optimized resource pages, and improved accessibility across devices.

The website was regularly updated with the latest federation news, committee activities, educational programmes, upcoming events, and important announcements, ensuring that members and stakeholders had timely access to accurate and relevant information.

2.5 Social Media Outreach

APFCB's digital presence expanded significantly in last two years through enhanced social media activities. Regular posts highlighted scientific content, event announcements, and key updates, complemented by targeted promotional campaigns for webinars. These efforts resulted in increased engagement across multiple platforms, strengthening APFCB's visibility within the region.

Social Media Links:

- Facebook: https://www.facebook.com/APFCB/
- Twitter: https://twitter.com/APFCB_LM
- Instagram: https://www.instagram.com/apfcb_lm/
- LinkedIn: https://www.linkedin.com/company/apfcb/
- YouTube: https://www.youtube.com/channel/UCoiicTsnVX-COjklgZHQ54Q

2.6 Collaboration with Corporate Members

The Communication & Publications Committee continued to foster strong and mutually beneficial collaborations with APFCB's corporate partners, recognizing their vital role in advancing the federation's educational mission. These strategic partnerships provided valuable support for the organization of webinars (QuidelOrtho), technical facilitation, and the development of high-quality educational content and digital resources. Through sustained industry engagement, the committee further strengthened APFCB's capacity to deliver impactful scientific programmes, expand its educational outreach, and enhance professional learning opportunities across the Asia-Pacific laboratory medicine.

2.7 Supports to the APFCB Executive Board

Communication & Publications Committee provided continuous support to the APFCB Executive Board by facilitating the timely dissemination of official communications, coordinating strategic outreach initiatives, and promoting federation activities across multiple platforms. The committee also played an integral role in enhancing APFCB's visibility during international conferences, national society meetings, and major scientific programmes, ensuring effective engagement with members, stakeholders, and the broader laboratory medicine community. These coordinated efforts further strengthened communication, collaboration, and the federation's regional and global presence.

3. Future Plans & Recommendations

Looking ahead, the Communication & Publications Committee envisions a more connected, innovative, and digitally empowered APFCB community. The committee will focus on strengthening engagement with member societies through structured dialogue and feedback mechanisms, ensuring that regional perspectives continue to shape educational priorities and communication strategies. Future initiatives will expand evidence-based surveys and translate their findings into impactful publications and targeted learning programmes.The committee also aims to diversify APFCB's scientific portfolio by introducing thematic publications, case-based educational content, featuring renowned experts from across the region. Leveraging emerging digital technologies, including advanced communication platforms and a dedicated APFCB Mobile Application, will further enhance access to educational resources and federation activities. Continued expansion of the APFCB Webcast & e-Learning Programme, greater involvement of early-career laboratory professionals, and stronger collaborations with member societies and corporate partners will remain central to the committee's vision of fostering scientific excellence, innovation, and regional leadership in laboratory medicine.

Report compiled by:

Prof. Pradeep Kumar Dabla (Chair)

Prof. Deepak Parchwani (Member)
& Team APFCB C-CP

APFCB Congresses and Conferences Committee (C-CC) Report

Members of the APFCB Congresses and Conferences Committee (C-CC) for the 2025–2026 term

Dr. Raja Elina Raja Aziddin (MACB)
Chair of C-CC

Dr Rajiv Ranjan Sinha (ACBI) – member

Ram Vinod Mahato (NACC) – member

Vincent Chen (SNIBE) - corporate member

Romina De Leon (Thermo Fisher Scientific) - corporate member

Role and responsibilities of the APFCB Congresses and Conferences Committee (APFCB C-CC)
The APFCB Congresses and Conferences Committee (C-CC) oversees the planning and organisation of APFCB Congresses and specialty regional meetings, with the aim of holding one specialty meeting

annually except in APFCB Congress years. The Committee evaluates applications for APFCB auspices for national, regional, and international meetings, collaborates with the Communication and Publications Committee (C-CP) to promote endorsed events. It is also responsible for ensuring that congresses and conferences comply with APFCB ethical and governance requirements for Ordinary and Corporate Members. In addition, together with the APFCB President, the Committee conducts a site visit to the APFCB Congress venue approximately one year before the Congress to review preparations with the local Organising Committee and support successful event delivery.

Activities of the APFCB C-CC conducted in 2025 to mid-year of 2026

1. **APFCB auspices were granted to the following APFCCB national societies for events held in 2025**

   i. **College of Chemical Pathologists of Sri Lanka (CCPSL) for the "10th Annual Academic Sessions 2025"** which was held on the 11th-12th July 2025 at the Monarch Imperia l Hotel, Colombo. The goal of the event included professional development of medical consultants, trainees and medical laboratory technologists.

   ii. **Malaysian Association of Clinical biochemists (MACB) for the "International Conference of Biochemistry, Molecular Biology and Laboratory Medicine 2025 (ICBMBLM 2025)" in** conjunction with the 35th MACB Annual Conference 2025 which was held on 25-27 August, 2025 at M Hotel, Petaling Jaya, Malaysia.

   The objective of the conference was to provide an avenue for members and the clinical laboratory community in Malaysia to discuss the latest scientific advancements and transformative innovations in clinical biomarker discovery, metabolic diseases, genetic research and lab technologies as well as breakthrough solutions that can applied to reshape the field and improve patient outcomes.

   In conjunction with the 35th MACB Conference, the APFCB also conducted a Pre-Conference Workshop on Method Verification on 25th August 2025, followed by a Symposium titled Building a Greener Tomorrow: Sustainability Strategies for Clinical Laboratories on Day 1 of the conference.

   iii. **Indonesian Association for Clinical Chemistry (IACC) for the event "XVII Indonesian Association for Clinical Chemistry (IACC) National Congress"** held at HARRIS Hotel and Conventions Malang, East Java, Indonesia from 4–7 September 2025.

   The objective was to foster collaboration and engagement among the Central Executive Board and regional committee members, while serving as a forum for strategic decision-making, organizational development, and policy direction. The event also aimed to share the latest scientific knowledge with clinical pathologists, general practitioners, medical residents, related science graduates, laboratory owners, and medical laboratory technologists through regular Scientific Meetings featuring field experts.

   iv. **Association of Medical Biochemists of India – Tamil Nadu Chapter (AMBI) for the event "AMBICON 2025, (32nd national conference of Association of Medical Biochemists of India**)" which took place in Coimbatore, Tamil Nadu, India, from 12th to 14th December 2025. The aim of the event was for knowledge sharing, professional development, networking and collaboration.

2. **APFCB auspices were granted to the following APFCCB national societies for evets held in 2026**

   i. Victorian Branch **of Australasian Association for Clinical Biochemistry and Laboratory Medicine (AACB)** and APFCB Working Group on Clinical Decision Support (WG-CDS) for the online webinar **"Evaluating large language models as clinical laboratory test recommenders in primary and emergency care"** which was held on 18 February 2026.

   This webinar aimed to equip laboratory professionals and clinicians with the knowledge to critically evaluate large language models as laboratory test recommenders, understand their limitations and safety risks, and define appropriate governance-led use of AI in primary and emergency care.

ii. **Chinese Association for Clinical Biochemistry (CACB)** for the event **"70 Years of Excellence, Leading the Future: New Frontiers in Laboratory Sciences and** Medical Biotechnology Symposium", held on 7 March 2026 at Lecture Hall 101, National Taiwan University College of Medicine. This event was in conjunction with the Joint academic symposium with Dept. of CLSMB, NTU to celebrate 70th anniversary.

iii. Roche Vietnam Company Limited in collaboration with **Vietnam Association of Clinical Biochemists (VACB),** Ho Chi Minh City Association of Clinical Biochemists, Ho Chi Minh City Medical Association, Association of Medical Laboratory Technologists, Accreditation Office for Standards Conformity Assessment Capacity for the event **"Vietnam Chemical Pathology Course XVI 2026 webinar".** This programme was held on 16 April 2026 and is part of the continuing education programme for medical laboratory scientists.

iv. **Iranian Scientific Association of Clinical Laboratory Doctors (IACLD)** for the **"17th International & 23rd National Congress on Quality Improvement in Clinical Laboratories"** in Milad Tower, Tehran – Iran on 5-8 May, 2026

Goals of the event included:

- Acquainting our specialists and researchers with world's latest clinical laboratory's scientific improvements and technological achievements.
- Acquainting the international scientists with capabilities of Iranian clinical laboratories.
- Making the managers of the country's clinical laboratories ready to plan for delivering better quality services to the patients and reinforcing the healthcare system.
- Utilizing the experiences of improves countries in the field of accreditation of laboratory system, and studying and writing laboratory-based methods.
- Quality and quantity improvement in clinical laboratory services for opposition against high level tumour marker tests and cancer genetic tests, regarding the increment of the mean age of the country's population and higher probability of the cancers' occurrence, meanwhile benefiting from other countries' experiences.
- Providing an appropriate situation for scientific negotiation between domestic and foreign scientists and brainstorming between them.
- Providing an appropriate situation for close collaboration between domestic manufacturers and importers and foreign companies in order to interchange the experiences and viewpoints and technology.
- Making an appropriate atmosphere for brainstorming between managers of the country's clinical laboratories and CEO of the manufacturers of laboratory kits and equipment, both domestic and foreign ones.
- Convergence between scientific and executive directors of the region's clinical laboratories in accordance with policies and goals of WHO and Ministry of Health.

v. **Nepalese Association for Clinical Chemistry (NACL) for the event "6th Annual NACC Conference"** on 30th May in Kathmandu, Nepal with the goal of Transforming Laboratory Medicine in Resource-Limited Settings: The Role of Point-of-Care Testing, Digital Integration, and Clinical Impact.

vi. **College of Chemical Pathologists of Sri Lanka (CCPSL) for their "Annual Academic Sessions CCPSL 2026"** held on 10th and 11th July 2026, Shragi – La Hotel, Colombo, Sri Lanka Specific goals of the event include professional development of medical consultants, trainees and medical laboratory technologists

vii. **Malaysia Association of Clinical Biochemists (MACB) for the "36TH MACB Annual Conference 2026 with the theme Data to Discovery: Shaping the Future of Biochemistry".** This event was held at Berjaya Times Square hotel, Kuala Lumpur from 13 – 15 July, 2026. A pre-conference workshop on Uncertainty of Measurement was held on 13 July, 2026.
The goal of the event was to promote scientific exchange, professional development, and collaboration in clinical biochemistry and laboratory medicine to enhance diagnostic quality and patient care.

viii. **Australasian Association for Clinical Biochemistry and Laboratory Medicine (AACB) for the "AACB 63rd Annual Scientific Conference 2026"** which will take place on 14 – 17 September, 2026, MCEC Melbourne Specific goals of the event: Focusing on the practical clinical laboratory, there will be 4 days of interactive workshops, clinical presentations from local and international speakers, oral and poster abstract presentations and industry symposia.

3. APFCB auspice was granted to the following APFCCB corporate member event held in 2025

i. **Roche Diagnostics Asia-Pacific Pte Ltd for the event "Breaking Boundaries in Clinical Mass Spectrometry"** held on 25 - 26 Nov 2025 at Cordis Hotel Hong Kong. The goal is to establish a collaborative user network to share expertise, exchange best practices, and drive advancements in the utilization of mass spectrometry.

4. APFCB auspice is granted to the following APFCCB corporate member event held in 2026

i. **Roche Diagnostics Asia Pacific for the event "Roche Experience Days 2026"** to be held on 14 & 15 October 2026 in Hopewell Hotel, Hong Kong. Specific goals of the event: To foster a forward thinking, thought leadership-focussed event that covers topics of interest to the broader clinical laboratory community.

5. Strategic and Educational Meeting

In addition to granting auspices, the C-CC has also been involved in planning scientific and education programmes for the APFCB members. The APFCB C-CC in collaboration with APFCB Scientific Committee, APFCB Education Committee and the Malaysian Association of Clinical Biochemists (MACB) will be organising an APFCB IQC Strategic and Educational Meeting on Laboratory Quality Control This meeting has received the support from Thermo Fisher Scientific and will take place at the Sunway Putra Hotel, Kuala Lumpur, Malaysia from 14–15 August 2026.

On Day 1 there will be a strategic meeting focused on collective discussion on the QC landscape, local needs and practice gaps in the region. The meeting will also be focus on identifying how current and novel QC practices can be applied to address these needs and gaps. At the end of this, the discussion points should be used to produce one or two papers specific to Asia Pacific. The two main thrusts of the discussions will be: QC practices in resource-limited setting and adoption of novel QC practices

Pic1: APFCB IQC Course Event flyer and scientific programme

National Society Report- ACBI, India

NAME OF SOCIETY	Association of Clinical Biochemists of India (ACBI)
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NAME OF PRESIDENT & EMAIL ADDRESS	President: **Prof. Indu Verma** Email: kpsacbi@yahoo.co.in
NAME OF NATIONAL REPRESENTATIVE TO APFCB & EMAIL ADDRESS	Prof. Rajiv Ranjan Sinha Email: kpsacbi@yahoo.co.in

From Innovation to Impact: Decoding the Scientific Architecture of IFCC WorldLab New Delhi 2026

Bernard Gouget (FR), Damien Gruson (BE), Swarup Shah (IN), Serafeim Karathanos (GR), Yan Liu (CN), Sven Ebert (CH), members of the IFCC ETD-EC - James O. Nichols (US), Laila Abdel-Wareth (UAE), Pradeep Dabla (IN) Anirban Ganguly (IN), Juha Rytkönen (FI), and Ebru Saatci (TR), members of the IFCC C-MHBLM

During recent monthly meetings of the IFCC Emerging Technologies Division Executive Committee (ETD-EC) and the Committee on Mobile Health and Bioengineering in Laboratory Medicine (C-MHBLM), members reviewed the scientific architecture of IFCC World Lab New Delhi 2026. As part of their preparations for the Congress, both Functional Units plan to maximize their participation across the programme by attending and reporting on a broad range of scientific sessions. This collective review led to the identification of eight major strategic axes that emerge throughout the Congress and reflect the future directions of laboratory medicine and healthcare. The accompanying figure summarizes this shared vision and is presented as a joint contribution of the ETD-EC and C-MHBLM, with the support of IFCC President Prof. Tomris Özben and our Indian colleagues hosting IFCC World Lab New Delhi 2026 (Rajiv Ranjan Sinha (Co-Chair, COC World Lab New Delhi 2026), Praveen Sharma, Co-Chair SPC, Indu Verma (President, ACBI), and Pradeep Dabla (member SPC, World Lab New Delhi 2026).

At first glance, the scientific architecture of IFCC World Lab New Delhi 2026 appears as an impressive collection of lectures, symposia, workshops, and scientific presentations spanning the full spectrum of laboratory medicine. A closer examination, however, reveals something even more significant. Beyond the diversity of topics, the Congress reflects a coherent vision of how laboratory medicine is evolving and how it will contribute to the future of healthcare. The accompanying figure captures this vision through eight interconnected strategic axes that emerge throughout the Congress scientific architecture. Together, they illustrate the transformation of laboratory medicine from its traditional analytical role into a key driver of clinical decision-making, public health, digital innovation, and healthcare resilience. More than a catalogue of scientific sessions, World Lab New Delhi 2026 presents a roadmap for the future. By bringing together innovation, precision medicine, global health, quality, leadership, ethics, integrated diagnostics, and sustainability, the Congress offers a comprehensive perspective on the challenges and opportunities that will shape healthcare in the years ahead.

The Eight Strategic Axes Emerging from IFCC WorldLab New Delhi 2026

1. **Digital Transformation and Artificial Intelligence**
   Digital technologies are no longer peripheral to laboratory medicine; they are becoming integral to its future. Multiple sessions address artificial intelligence, big data, automation, interoperability, cybersecurity, blockchain technologies, and resilient laboratory information systems. Collectively, they highlight the transition toward digitally connected laboratories capable of generating actionable clinical intelligence from increasingly complex datasets.
2. **Precision Medicine and Omics**
   Advances in genomics, cyto-genomics, metabolomics, liquid biopsy, cell-free DNA, and molecular biomarkers are transforming diagnostics and patient management. The Congress reflects the growing convergence between laboratory medicine and precision healthcare, where biological information increasingly guides personalized prevention, diagnosis, and treatment strategies.

3. **Global Health and One Health**
   The opening lecture on tuberculosis immediately establishes the global health dimension of the Congress. Additional sessions addressing antimicrobial resistance, infectious diseases, diabetes, cardiovascular disorders, environmental exposures, and public health challenges reinforce the essential contribution of laboratory medicine to population health, disease surveillance, prevention, and healthcare preparedness.

4. **Trust, Quality and Metrology**
   Innovation can only create value when supported by confidence in laboratory results. Method evaluation, harmonization, measurement uncertainty, traceability, and metrology remain fundamental pillars throughout the Congress, ensuring that scientific progress continues to be supported by robust, reliable, and clinically meaningful measurements.

5. **Leadership, Management and Workforce Development**
   Technological advances alone will not shape the future. Several sessions focus on laboratory leadership, management, communication, education, and workforce development, emphasizing the importance of investing in people, skills, and organizational excellence to support sustainable transformation.

6. **Ethics, Governance and Data Sovereignty**
   As artificial intelligence and digital technologies become increasingly integrated into healthcare, ethical and governance issues gain greater importance. The Congress addresses scientific integrity, responsible use of data, patient privacy, cybersecurity, and regulatory frameworks, recognizing that innovation must remain aligned with societal expectations, public trust, and patient interests.

7. **Integrated Diagnostics and Clinical Impact**
   One of the most important evolutions in modern healthcare is the move toward integrated diagnostics. Laboratory medicine is increasingly working alongside pathology, genomics, clinical medicine, and digital technologies to provide more comprehensive and clinically meaningful diagnostic pathways. This theme culminates in the EFLM Symposium dedicated to integrative diagnostics and coordinated patient care.

8. **Resilient and Sustainable Healthcare Systems**
   Underlying all other themes is a broader objective: strengthening the resilience of healthcare systems. Whether confronting pandemics, antimicrobial resistance, environmental threats, workforce shortages, or cyberattacks, laboratory medicine is increasingly recognized as a strategic component of sustainable healthcare infrastructures capable of supporting better health outcomes for populations worldwide.

A Truly Global Perspective: The strength of this vision lies not only in the breadth of the Congress scientific architecture, but also in the diversity of perspectives that contribute to it. The Congress highlights the unique expertise of the IFCC Regional Federations, each bringing experience shaped by distinct healthcare priorities, challenges, and opportunities.

- APFCB contributes leadership in newborn screening, environmental health, toxicology, and population-based approaches.
- AFCB highlights cardiovascular medicine, genomics, personalized healthcare, and cybersecurity.
- AFCC focuses on access, sustainability, therapeutic drug monitoring, and implementation in resource-limited settings.
- COLABIOCLI emphasizes infectious diseases, surveillance, prevention, and community-based healthcare strategies.
- NAFCC showcases innovation in biomarkers, genomics, artificial intelligence, and precision medicine.
- EFLM explores integrated diagnostics, multidisciplinary collaboration, and future competencies for laboratory professionals.
- ACBI and India, as host partners, bring strong expertise in oncology, diabetes, tuberculosis, digital health, healthcare innovation, and large-scale implementation of emerging technologies.

Together, these contributions create a truly global scientific dialogue and demonstrate how regional innovation can help address common healthcare challenges worldwide. The eight strategic axes illustrated in the accompanying figure are more than emerging scientific trends. Together, they represent a shared roadmap for the future of laboratory medicine and healthcare. Their successful implementation will depend on collaboration across the entire laboratory medicine ecosystem. IFCC WorldLab New Delhi 2026, therefore, provides a unique opportunity for IFCC Functional Units to meet, interact, and contribute actively to the Congress while strengthening collaboration with Full Members, Affiliate Members, Regional Federations,

Corporate Members, academic institutions, healthcare organizations, industry partners, and young professionals.The Congress also offers an exceptional platform for the in vitro diagnostics industry, biotechnology companies, digital health innovators, artificial intelligence developers, pharmaceutical partners, medical technology companies, and emerging start-ups. The scientific themes of WorldLab closely mirror the technological transformations currently reshaping healthcare, creating an ideal environment for dialogue between science, clinical practice, industry, and policy leaders.

By bringing together expertise from every region of the world, New Delhi 2026 will provide a unique environment to transform ideas into collaborations, innovation into implementation, and scientific advances into measurable healthcare impact. We, therefore, encourage all IFCC Functional Units, Member Societies, Affiliate Members, Regional Federations, Corporate Members, industry partners, and stakeholders across the healthcare ecosystem to be actively represented in New Delhi and to contribute to this global conversation shaping the future of healthcare. As French writer and former Minister of Culture André Malraux once said, **"Great dreams inspire great actions."** WorldLab New Delhi 2026 is where ideas become innovations, ambitions become achievements, and the global laboratory medicine community comes together to build the future of healthcare.

Welcome to IFCC WorldLab New Delhi 2026. Be part of the conversation.
Be part of the future.
Help shape it.

Prepared by the IFCC ETD-EC and C MHBLM in collaboration with WorldLab New Delhi 2026 ACBI representatives.

National Society Report – CACB, Taiwan

NAME OF SOCIETY	Chinese Association for Clinical Biochemistry (CACB-Taiwan)
OFFICIAL SOCIETY EMAIL ADDRESS	office@cacb.org.tw
NAME OF PRESIDENT & EMAIL ADDRESS	Sandy Huey-Jen Hsu sandyhsu@ntu.edu.tw
NAME OF NATIONAL REPRESENTATIVE TO APFCB & EMAIL ADDRESS	Woei-horng Fang whfang@ntu.edu.tw

Report on society activities

CACB Annual Conference and Scientific Symposium

2026 The CACB annual conference and scientific symposium were held in conjunction with the 40th Joint Annual Conference of Biomedical Science (JACBS) on March 21st and 22nd, 2026, at the National Defense Medical Center. Embracing the theme of the 40th anniversary, Innovative Healthcare and Biomedical Technologies in the AI Era, CACB focused its symposium on AI-powered Precision Medicine.
The conference featured distinguished keynote speakers, including:
Dr. Chi-Huey Wong, who presented Decoding Protein Glycosylation for Better Vaccine and Antibody Development.
Mr. Miin Wu (Chairman of Macronix), who presented the intersection of semiconductors and AI in creating new medical miracles.
The CACB scientific sessions included expert presentations on:
The development of next-generation medical information platforms by Prof. Tsz-Yin Chang.
AI-powered multi-omics data analysis for precision medicine by Prof. Chien-Yu Chen.
AI-ECG applications for dyskalemia by Prof. Shih-Hua Lin.
Leveraging AI to redefine the value and role of biochemical work by Prof. Ming-Der Lai.

Photo 1: Opening ceremony of the 40th JACBS. Presidents of the participating academic societies pose for a group photograph. (Dr. Sandy Hui-Chen Hsu, CACB president, is third from the right)

Photo 2: CACB board members and invited speakers at the 40th JACBS. (Dr. Sandy Hui-Chen Hsu, CACB president, is third from the left)

Photo 3: Winners of the oral contest and CACB president and board members, Dr. Sandy Huey-Jen Hsu (center-left)

Initiative for Clinical Laboratory Consultation Services Beyond academic exchange

CACB is actively spearheading a pilot project to promote Clinical Laboratory Consultation Services. A dedicated meeting was held on May 13th, 2026, to discuss the application status of the Deep Cultivation Project with the Ministry of Health and Welfare. While clinics and laboratory centers are currently eligible for the first phase, CACB is proactively discussing the eligibility of professional societies for the second phase. To further this initiative, the association is planning a Symposium on Clinical Laboratory Consultation Services to be held at the NTUH International Convention Center.

Celebrations and Academic Recognition

To mark the 40th anniversary of JACBS, a commemorative retrospective video featuring AI-enhanced historical photos was showcased. CACB also fostered young talent through rigorous competitions, featuring 8 oral presentations and 31 poster presentations. The poster awards were generously sponsored by the Y.S. Li Tien-te Medical and Pharmaceutical Foundation.

Photo 4: Winners of the poster contest and CACB president and board members, Dr. Sandy Huey-Jen Hsu (center-left)

International Engagement and Future Outlook

CACB continues its commitment to international collaboration, recently voting to support the Cameroon Society of Clinical Biology in joining the IFCC. Members are also encouraged to participate in the upcoming Asian Clinical Mass Spectrometry Symposium in April 2026. Looking forward, CACB remains dedicated to integrating AI into clinical biochemistry and inviting new talents to join us in advancing precision healthcare.

Upcoming events for 2026:

Clinical Laboratory Consultation Pilot Project (Phase 2): Following the initial discussions with the Ministry of Health and Welfare regarding the Deep Cultivation Project, CACB will closely monitor the official announcements expected in the second half of 2026. The association is actively preparing to apply for the second phase of this pilot project, which aims to further integrate professional consultation services into clinical laboratory practices.

Preparation for the 18th APFCB Congress 2027: CACB proposed Symposium “Translational Smart Laboratory Medicine: Transforming Clinical Diagnostics and Shaping the Future of Healthcare” was accepted by the COC. Prof Kang-Yi Su, Dr. Tjan-Shing Jap, and A/Prof Wei-Ling Lin. This symposium will highlight innovations in laboratory medicine and explore how technological integration and translational research are shaping the future of clinical diagnostics. By bringing together experts across disciplines, the session aims to foster dialogue and advance the next generation of smart laboratory medicine.

Talent Recruitment and Industry Collaboration: Throughout the remainder of 2026, CACB will continue to actively invite emerging talents from the fields of academia, medicine, and clinical biochemistry to join our ranks. We also remain committed to strengthening our partnerships with the biotechnology industry and enhancing our engagement with international clinical biochemistry organizations.

Report Submitted by:

Dr. Woei-horng Fang, CACB-Taiwan

National Society Report – AMBI, India

NAME OF THE SOCIETY	Association of Medical Biochemists of India (AMBI)
OFFICIAL SOCIETY EMAIL ADDRESS	drvgovindaraju@gmail.com
NAME OF NATIONAL REPRESENTATIVE TO APFCB & EMAIL ADDRESS	Dr Shanthi Naidu, naidukambi@gmail.com

Submitted by:
Honorary Secretary, AMBI Head Office
Dr Anitha Devanath

Annual Conference of AMBI (AMBICON 2026) will be held in All India Institute of Medical Sciences, Mangalagiri, Andhra Pradesh during 9th to 12th December, 2026.

Report On AMBI Academics

AMBI Academics is a series of national webinar-based educational activities conducted by AMBI Academic Branch. During the last six months, three webinars were held:

S No.	Date	Topic	Speaker details
01	24.03.2026	From Cancer Evolution to Immunotherapy: Biochemical Basis and Clinical Translation	Dr Shubhangi Rathod Asst Professor, GCS Medical College, Ahmedabad
02	24.04.2026	A Day at the Laboratory: Translating Accreditation into Practice	Dr Yogesh R Pawade Prof. & Head, AIIMS, Nagpur
03	22.05.2026	Liver: From Biochemistry to Bedside Liver Biochemistry Liver Function Tests We are What we Eat	Dr MP Saravanan Prof. & Head, Govt. Stanely Medical College, Chennai Dr Aalia Tahseen Senior Resident, AIIMS, Bhubaneswar Dr Aparna Varma Additional Prof., AIIMS, Bibinagar

Report on AMBI Task Force

AMBI has formulated guidelines for the following Task Force:

i. Kidney diseases: Relevance of NGAL and KIM-1 as markers of Acute Kidney injury in Indian Population.
ii. Medical Education: Adequacy of the CBME curriculum regarding course content and methodology of teaching.
iii. Cardiovascular diseases: Relevance of using wearables for monitoring cardiovascular health in Indian context.
iv. Inherited Metabolic disorders
v. Ethics in Laboratory Medicine
vi. Myeloma and related disorders: Immunofixation and immunotyping
vii. Laboratory Stewardship: Promoting appropriate usage of laboratories
viii. Young scientists

Report on Branch Academic Activities

S No.	Date	Topic of the academic Event	Host/Branch conducting the academic activity
01	21.01.2026	CME on Point of Cardiology in Critical care	Dept of Biochemistry, Murshidabad Medical College and hospital, Murshidabad, West Bengal
02	04.02.2026	CME on Haemoglobinopathy: Current trends & future directions	Dept of Biochemistry, KIMS, Karad, Maharashtra
03	08.02.2026	CME on Exploring Fallacies in Laboratory	Dept of Biochemistry, Parul Institute of Medical Sciences & Research Vadodara, Gujarat
04	27.02.2026	CME on Learning Artificial Intelligence In Laboratory Medicine using non-code tools	Dept of Biochemistry, KPC Medical College, Jadavpur, Kolkata
05	27.02.2026	Workshop on Transforming Laboratory Management Data decisions	Dept of Biochemistry, IPGME & R and SSKM Hospital, Kolkata
06	27.03.2026 to 28.03.2026	3rd State level conference – Kerala Chapter	Dept of Biochemistry, GMC, Kozhikode, Kerala
07	11.04.2026 to 12.04.2026	CME on Method Verification & Validation- A CLSI Perspective	Dept of Laboratory Medicine, CARE Hospitals, Hyderabad
08	17.04.2026 to 19.04.2026	5th national postgraduate Update – Workshop & Conference " Virtual Bio-Connect"	Dept. of Biochemistry GMCH, Chandigarh
09	07.05.2026	CME on New Horizons of biochemistry: From Innovation to Bedside	Dept of Biochemistry, ICare Institute of Medical Sciences and Research, Haldia West Bengal
10	15.05.2026	CME on Good Clinical Laboratory Practices	ABVIMS, Dr RML Hospital, New Delhi
11	05.06.2026	CME on Diabetes 360	Dept. of Biochemistry, Lakhimpur Medical College, Assam
12	12.06.2026 to 13.06.2026	State level Conference- Telangana Branch Frontiers in Lab Medicine – Total Lab Automation & Liver Care	Department of Biochemistry NIMS, Hyderabad Telangana
13	25.06.2026 to 27.06.2026	11th State level Conference – Karnataka Chapter (AMBKCCON)	Dept of Biochemistry, Vydehi Medical College, Bengaluru

National Society Report – SACB, Singapore

Name of Society	Singapore Association of Clinical Biochemists (SACB) (www.sacb.org.sg)
President (APFCB Representative)	Dr Leslie Lam Email: leslie.lam@parkwaylabs.com.sg
Vice-President	Dr Tan Jun Guan
Treasurer	Mr Johnson Setoh
Secretary	Dr Kho Shu Hui
Assistant Secretary	Ms. Chong Ai Teng
Council Members	Ms. Joanne Lee Ms Ummi Kulsum Ms Siti Ramlah
Co-opted members	Ms Andrea Goh Ms Ho Mun Jun

Submitted by:

CHONG AI TENG

ANNUAL SCIENTIFIC MEETING 2026

The Singapore Association of Clinical Biochemists (SACB) successfully held its Annual Scientific Meeting (ASM) and Annual General Meeting (AGM) on 11 April 2026 at the One Farrer Hotel Grand Ballroom, Singapore. This full-day event, running from 0800 to 1630, brought together over 180 participants, including members, healthcare professionals, and industry partners, reflecting the continued growth and strong engagement within the clinical biochemistry community.

The meeting commenced with registration and breakfast, followed by the Opening Address by Dr Leslie Lam, President of SACB, who warmly welcomed delegates and set the tone for a day of scientific exchange and collaboration. The Annual General Meeting (AGM) was held mid-morning, after the coffee break, during which members were updated on SACB's activities, developments, and initiatives over the past year.

The scientific programme featured a comprehensive and diverse series of presentations delivered across plenary and parallel sessions, reflecting current developments and innovations in clinical biochemistry and laboratory medicine.

Figure 1. List of topics and corresponding speakers.

In addition to the rich scientific content, the event provided valuable opportunities for networking during breaks and lunch, with a vibrant exhibition area where sponsors and vendors showcased their latest diagnostic technologies and solutions. Their strong support contributed significantly to the success of the meeting.

The ASM 2026 concluded with the Closing Session by Dr Leslie Lam, marking the end of a productive and engaging scientific meeting. Overall, ASM 2026 exemplified SACB's continued commitment to advancing laboratory medicine, fostering professional development, and strengthening collaborations between clinicians, laboratory professionals, and industry partners. The high level of participation and the breadth of topics presented underscored the importance of this annual platform in driving innovation and improving patient care outcomes.

Figure 2. Compilation of event highlights.

Figure 3. Compilation of industry partners.

Figure 4. Post-ASM dinner with the speakers.

ANNUAL GENERAL MEETING 2026

The Singapore Association of Clinical Biochemists (SACB) convened its Annual General Meeting (AGM) on 11 April 2026 at the One Farrer Hotel Grand Ballroom, Singapore, held in conjunction with the Annual Scientific Meeting (ASM). The AGM was well attended by SACB members and formed an integral part of the day's programme, continuing the Association's tradition of fostering transparency, accountability, and member engagement.

During the AGM, Dr Tan Jun Guan, SACB Treasurer at the time (subsequently elected as Vice President), presented the Association's financial report, providing a comprehensive overview of SACB's financial performance and status over the past year. In addition, members were updated on the Association's key activities, achievements, and initiatives undertaken during the preceding year, reflecting SACB's ongoing efforts to advance clinical biochemistry and laboratory medicine in Singapore.

A key highlight of the AGM 2026 was the election of council members for the year 2026 to 2028, where SACB professional members exercised their voting rights to appoint leadership for the upcoming term. This election process underscores SACB's commitment to strong governance and active member participation, ensuring that the Association continues to be guided by dedicated professionals representing the interests of the clinical laboratory community.

The AGM also served as an important platform for members to engage in open dialogue, raise questions, and provide feedback on SACB's direction and initiatives. Such interactions are vital in strengthening the sense of community and collaboration within the Association, as well as in shaping its future strategies.

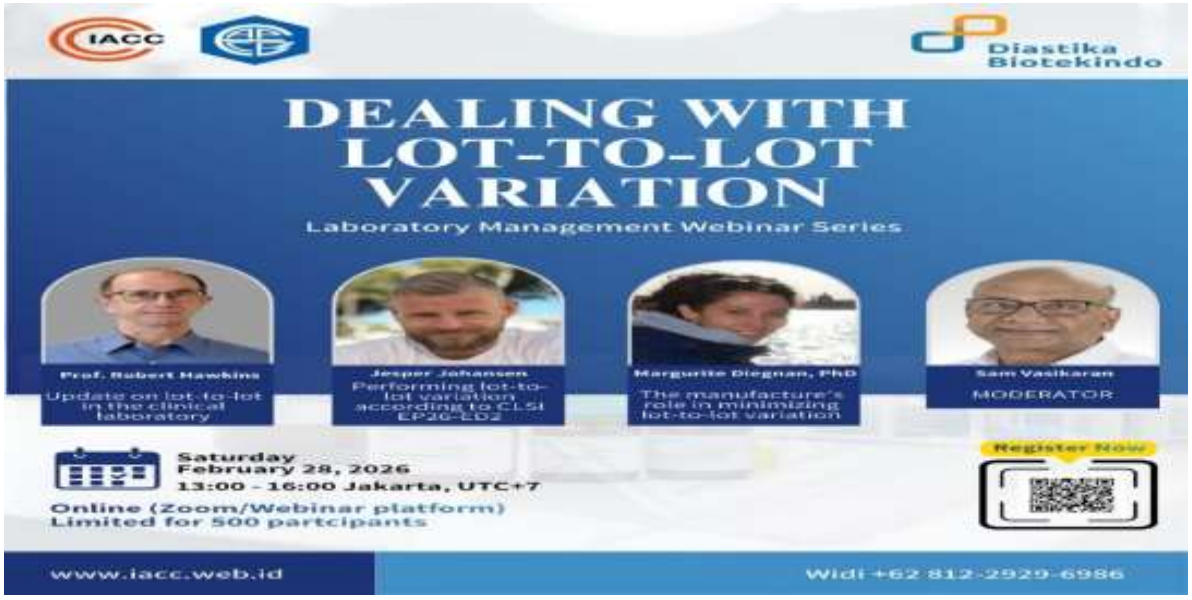
Overall, the AGM 2026 was successfully conducted, reflecting the continued support and active involvement of SACB members. It remains a cornerstone event that reinforces the Association's commitment to good governance, professional development, and the advancement of laboratory medicine.

Figure 5. Left: Photo taken during AGM. Right: New council members (Left to right: Ms Chong Ai Teng, Ms Siti Rahmah, Ms Joanne Lee, Dr Leslie Lam, Ms Ummi Kulsum, Ms Ho Mun Jun, Dr Kho Shu Hui. Missing: Dr Tan Jun Guan, Mr Johnson Setoh, Ms Andrea Goh)

PERKUMPULAN KESEMINATAN KIMIA KLINIK DAN LABORATORIUM INDONESIA
INDONESIAN ASSOCIATION FOR CLINICAL CHEMISTRY

NAME OF SOCIETY	**Indonesian Association of Clinical Chemistry (IACC-Indonesia)**
OFFICIAL SOCIETY EMAIL ADDRESS	secretariat@iacc.web.id
NAME OF PRESIDENT & EMAIL ADDRESS	Dr. dr. Lia G Partakusuma, Sp.PK(K), MM, MARS, FAMM liagp16@gmail.com
NAME OF NATIONAL REPRESENTATIVE TO APFCB & EMAIL ADDRESS	Sri Paulani, M.S.M, Apt., SSi hkki.secretariat@gmail.com and sri.paulani@prodia.co.id

APFCB – IACC Webinar Series 1
"Dealing with Lot-to-Lot Variation"
Saturday, 28 February 2026



The session featured three speakers: **Prof. Robert Hawkins** (Update on Lot-to-Lot Variation in the Clinical Laboratory), **Mr. Jesper Johansen** (Performing Lot-to-Lot Variation According to CLSI EP26-ED2), and **Ms. Marguerite Deignan, Ph.D.** (The Manufacturer's Role in Minimizing Lot-to-Lot Variation).

The program aimed to enhance the understanding and practical competencies of clinical laboratory professionals in managing lot-to-lot variation, a key factor affecting the accuracy and consistency of laboratory test results. The program discussed the clinical significance of lot-to-lot variation, its common sources (including reagents, calibrators, and analytical systems), and its impact on patient results. Participants were also introduced to methods for monitoring variation using internal quality control (IQC) data and patient-based trends, supported by appropriate governance and documentation practices.

The program further covered the implementation of CLSI EP26-ED2, including selection of measurands, establishment of clinical decision limits, patient sample selection with commutability considerations, statistical comparison between reagent lots, acceptance criteria, and practical workflow integration in routine laboratory practice. In addition, the manufacturer's role in minimizing lot-to-lot variation was highlighted, including lot release testing, traceability systems, change notifications, stability studies, and harmonization strategies.

On 1 March 2026, the President IACC, dr Lia G. Partakusuma attended the **International Symposium on Laboratory Medicine** held in Shenzhen, a prestigious international forum that brought together global experts in clinical chemistry, laboratory medicine, and in vitro diagnostics. The symposium served as a platform for scientific exchange on recent advancements, innovation, and sustainability in laboratory medicine, and was organized within the framework of a strategic collaboration between the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) and industry partners, including Snibe.

During the event, and member of the IFCC Task Force on Environmental Impact of Laboratory Medicine (TF-EILM), delivered a keynote presentation titled "Green Lab Transformation: A Strategic Blueprint for Reducing Costs and Environmental Impact in Asian Hospitals." She highlighted key strategies including resource efficiency, waste reduction, cost optimization, and global collaboration, emphasizing the importance of sustainable laboratory practices in improving healthcare systems across Asia while reducing environmental impact.

IACC and Partners Support Post-Disaster Healthcare Services in Aceh Province, Indonesia 6 May 2026


PEDULI ACEH


PEDULI ACEH
PEDULI ACEH

The Indonesian Association for Clinical Chemistry (IACC), together with its partners, carried out a humanitarian assistance program on 6 May 2026 to support post-disaster healthcare recovery efforts in Aceh Province, Indonesia, following recent natural disaster events in the region. The assistance was specifically directed to RSP Rantau (Rantau General Hospital) and RSUD Aceh Tamiang as part of efforts to restore healthcare services and strengthen clinical laboratory capacity in the affected areas.

The support provided to RSP Rantau included laboratory equipment and essential supplies to enhance diagnostic services, as well as materials and financial assistance for laboratory facility refurbishment, including repainting activities. RSUD Aceh Tamiang also received laboratory equipment, information technology support, and other essential items to strengthen operational capacity.

Through this initiative, IACC and its partners reaffirmed their commitment to improving laboratory services and supporting healthcare system recovery in post-disaster settings.

LABTALK INDONESIA
Powering the Future of Smart Laboratories
Shangri-La Hotel
Saturday, 16 May 2026

The event was held as a hybrid scientific program bringing together clinicians, laboratory professionals, and industry stakeholders to discuss advancements in laboratory medicine and digital transformation. A total of 328 participants attended, consisting of 114 onsite participants and 214 online participants. The opening session featured welcoming remarks from representatives of Shenzhen Mindray Bio-Medical Electronics Co., Ltd. and PT Mindray Medical Indonesia, along with scientific and institutional greetings from Indonesian Association for Clinical Chemistry (IACC), PDS PatKLIn, and the Indonesian Ministry of Health.

The scientific program highlighted key topics in laboratory innovation, including the future of laboratory automation, AI-driven laboratory ecosystems, and intelligent laboratory management systems such as Mindray Innolab and MT-8000 solutions. Sessions were delivered by national and international experts, followed by interactive discussions and Q&A. The program concluded with a product launching segment, door prize session, and closing remarks, emphasizing the integration of advanced technology, connectivity, and artificial intelligence in shaping the future of clinical laboratories.

"Navigating Clinical Molecular Technologies:
Understanding Platforms, Strengths, and Strategic Fit"
Saturday, 23 May 2026

Focusing on the evolving landscape of molecular technologies in clinical practice, highlighting their applications, advantages, limitations, and strategic role in supporting precision medicine. It aimed to strengthen participants' understanding of how molecular diagnostic platforms can be optimally utilized in clinical decision-making.

The session featured Lyana Setiawan, M.D., PhD, who discussed the clinical application of molecular testing across the continuum of precision medicine, from prediction and diagnosis to disease monitoring, and Theodora Rahardja, who presented the molecular technology landscape, including key advantages and limitations of various platforms. The discussion was moderated by Britania Atrika, facilitating an engaging exchange of insights on the strategic fit of molecular technologies in modern healthcare practice.

APFCB – IACC Webinar Series 2
"Reference Range and Clinical Decision Limit"
Saturday, 30 May 2026

The webinar featured three distinguished speakers:
Dr. Pradeep Kumar Dabla (IFCC), who discussed the principles of reference interval concepts including CLSI/IFCC approaches, transference versus establishment, partitioning by age, sex, and ethnicity, as well as verification steps for local populations and proper documentation and reporting.

Prof. Ken Sikaris (AACB) elaborated on the distinction between reference intervals and clinical decision limits, providing clinical examples such as cardiac markers, lipids, and HbA1c, and highlighting result interpretation, reporting practices, critical values, and patient safety implications.

Dr. Tony Badrick (APFCB) presented case-based scenarios addressing common laboratory pitfalls such as inappropriate use of limits, assay changes, and unit inconsistencies, and emphasized effective communication of reference changes, harmonized reporting, and engagement with clinicians and governance committees.

The session was moderated by **Dr. July Kumalawati (IACC).**

Inauguration of the IACC Balikpapan East Branch and IACC Balikpapan Laboratory Update 2026
Balikpapan, 20 June 2026

The Indonesian Association for Clinical Chemistry (IACC) officially inaugurated the IACC Balikpapan East Kalimantan Branch on 20 June 2026 at Sakura Hall, Dr. Kanujoso Djatiwibowo Regional Hospital, Balikpapan, East Kalimantan.

With this inauguration, the Balikpapan Branch became the 16th regional branch of IACC, marking an important milestone in the Association's continued efforts to strengthen its national network and expand professional engagement across Indonesia.

The inauguration was held in conjunction with the IACC Balikpapan Laboratory Update 2026, themed "Strengthening Laboratory Medicine Through Quality Management and Morphological Expertise." The event featured a scientific seminar and a specialized workshop for clinical pathologists (SpPK), providing a platform for knowledge sharing, professional development, and discussion on quality management and morphological expertise in laboratory medicine.

MALAYSIAN ASSOCIATION OF CLINICAL BIOCHEMISTS (MACB)

Name of Society	MALAYSIAN ASSOCIATION OF CLINICAL BIOCHEMISTS (MACB)
Email	MACB_secretary@yahoo.com
Name of President & National Representative	Raja Elina Raja Aziddin E-mail:rajaelina@gmail.com, president@macb.org.my
Secretary	Chuo Pek Ham E-mail:phchuo@yahoo.com, MACB_secretary@yahoo.com

Activities carried out from Jan – Jun 2026

The Malaysian Association of Clinical Biochemists (MACB) has organized a full lineup of events in 2026, including its annual conference, practical workshops, and online webinars.
The MACB's Jan- Jun 2026 calendar includes several webinars. Early in the year, the association focused on heart health with the theme " Latest Guidelines on the Measurement and Reporting of Lipids and Lipoproteins" (12 January 2026) and another on "Lipid Updates 2026: From Diagnostics to Therapy" (17January 2026). Both events covered new updates on lipid testing.

Pic 1: Webinar: "Latest Guidelines on the Measurement and Reporting of Lipids and Lipoproteins"

Pic 2: Webinar: "Lipid Updates 2026: From Diagnostics to Therapy"

Mid-year events focused on body health and daily laboratory work, featuring the "Rethinking Obesity: What Every Laboratorian Should Know" webinar (10 June 2026) to look at health risks beyond standard weight.

Pic 3: Webinar: "Latest Guidelines on the Measurement and Reporting of Lipids and Lipoproteins"

The IFCC task Force – Young Scientists (IFCC TF-YS): perspectives for young scientists in 2026

Marie LENSKI
French YS (Société Française de Biologie Cliniques SFBC)
IFCC-TF-YS chair
Web: https://ifcc.org/task-force-young-scientists-tf-ys

The IFCC TF-YS supports the development, engagement, and international integration of early-career professionals in laboratory medicine. In 2026, four of the core members are continuing their appointments and welcoming two new core members. This new TF-YS is highly motivated to continue ongoing activities and looks forward to developing impactful initiatives to further support young scientists worldwide. This is possible thanks to a dynamic network of over 40 corresponding members representing national societies across all regions.

A major highlight of 2026 will be the IFCC WorldLab Congress in New Delhi, where TF-YS will coordinate a programme dedicated to young scientists (YS). Several core activities are planned, with four flagship initiatives: the Young Scientists Forum (5th Edition), a scientific platform where selected YS present their work to an international audience, enhancing both visibility and scientific communication skills; the Young Scientists Poster Tours, interactive sessions designed to develop presentation skills through short pitches and group discussions in a supportive environment; Laboratory Visits, an opportunity to explore laboratory practices in a different healthcare setting, promoting technical exchange and global benchmarking; and the Young Scientists Social Event, a key networking moment fostering informal interactions. We hope to see many of you at WorldLab in New Delhi 2026.
Education remains a cornerstone of the TF-YS's activities. Its programme of webinars and Diagnostic Dialogues, which regularly attracts 100 to 300 participants from all continents, will be further enhanced in 2026. The programme will continue to offer webinars and case-based discussions while expanding its scope to cover new topics, including digital competences in laboratory medicine. The involvement of young scientists as speakers and moderators will be increased, providing them with a unique platform for knowledge exchange and professional growth.

Beyond scientific knowledge, the TF-YS is committed to developing essential professional skills among young scientists, including leadership skills. This effort will be supported through initiatives such as leadership workshops and involvement in international projects, which are key to supporting this transition. TF-YS will also support new mentoring activities between young scientists and experienced professionals.

Skill transfer within the YS community is also a core principle of TF-YS. TF-YS has already supported the creation of a thematic group of YS on digital competences, with the aim of encouraging peer mentoring within the YS community. Additional thematic groups are expected to emerge from YS in the near future. And of course, IFCC TF-YS is always happy to support young scientists in developing and sharing new ideas or initiatives.

The TF-YS expresses its sincere gratitude to the IFCC and its Executive Board for their continuous support, as well as to all young scientists involved in its activities worldwide. Their enthusiasm, engagement, and collaborative spirit define the Task Force as a dynamic, supportive, and inspiring community. Finally, TF-YS warmly thanks Dr. Santiago Fares Taie for his two terms as Chair, his outstanding commitment, and his impactful work in building the strong and connected global community of young scientists in laboratory medicine that exists today.

Information on all mentioned activities, objectives and projects of the TF-YS are available on the IFCC website: https://ifcc.org/task-force-young-scientists-tf-ys/, or follow us on Instagram, Facebook, LinkedIn. We would also encourage YS to reach out to IFCC corresponding members in their country (list on our website) or to connect directly with TF-YS core members.

IFCC TF-YS core members

YOUNG SCIENTIST INTERVIEW

Won Seok, Jung, MS, MT(KAMT), MLS(ASCPi)

Affiliations & Associations:

- Department of Laboratory Medicine, Samsung Medical Center, Seoul, South Korea
- Executive Secretary of the Korean Society of Clinical Laboratory Chemistry (KSCLC)
- Member of the Korean Association of Medical Technologists (KAMT)

Q1. Please Introduce Yourself?

My name is Won Seok, Jung, MS, MT (KAMT), MLS (ASCPi). I am a Medical Technologist working in the special chemistry laboratory within the Department of Laboratory Medicine at Samsung Medical Center (SMC) in Seoul, South Korea. My career at SMC began in 2008.

In South Korea, medical technologists typically rotate through various sub-disciplines to gain comprehensive clinical experience. Over my 18-year career, I have worked in the hematology Laboratory, the Blood Bank, and the Immunology Laboratory for histocompatibility and transplantation testing (HLA). I also spent over 5 years in the Clinical Chemistry Laboratory, primarily handling night shifts to manage urgent and routine biochemical testing. This experience across different core sections provided me with a solid practical foundation before I joined the Special Chemistry Laboratory 3 years ago.

Alongside my hospital duties, I pursued my graduate education and earned a Master of Science in Integrated Biomedical and Life Sciences from the Graduate School. Balancing full-time clinical shifts with graduate studies allowed me to systematically connect daily bench work with laboratory science theory.

To maintain professional standards, I have obtained the following certifications:

- Chemical Specialist Medical Technologist Certification from the Korean Association of Medical Technologists (KAMT, 2024)
- International Medical Technologist (MT/MLS) Certification from the American Society for Clinical Pathology (ASCPi, 2013)
- International Medical Laboratory Technician (MLT) Certification from the American Society for Clinical Pathology (ASCPi, 2007)

Currently, I also serve as the Executive Secretary of the Korean Society of Clinical Laboratory Chemistry (KSCLC), where I manage administrative tasks and support national symposiums to contribute to our professional community.

Q2. What is your main working focus?

My main operational focus is on the routine analysis and maintenance of Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS) systems within the Special Chemistry Laboratory. My role requires technical precision and steady quality control to ensure data reliability.

Over the past 3 years, my responsibilities have focused on several specialized testing areas:

- Therapeutic Drug Monitoring (TDM): I manage the quantification of immunosuppressants and antifungal drugs, ensuring that critical drug concentration data are accurately reported before patient consultations.
- Metabolic & Specialized Endocrinology Panels: I perform the extraction and quantification of plasma and urinary metabolites for specialized endocrine screenings, alongside routine metabolic markers.
- Advanced Electrophoresis: I operate Capillary Electrophoresis (CE) systems for specific biomarker testing used in healthcare screenings.
- Newborn Screening (NBS): I oversee mass spectrometry-based acylcarnitines profiling for newborn screening of inborn errors of metabolism, which is managed alongside automated hormonal and enzymatic immunoassays.

Q3. What are other areas of interest for you?

My other area of interest involves organizing academic conferences and fostering practical technical exchanges between healthcare institutions, both domestically and internationally.

In 2025, I participated in the Joint International Exchange and Educational Program between KAMT (Korea) and TAMT (Taiwan), spending a week at the Linkou Chang Gung Memorial Hospital in Taiwan. This cross-training was a valuable opportunity to share practical information regarding the principles and applications of mass spectrometry-based testing.

In addition to international programs, I am deeply involved in supporting our domestic laboratory community. Through my role as Executive Secretary for the KSCLC, I manage the operational planning and administrative coordination for our biannual national symposiums, held every spring and autumn. In this role, I focus on providing a reliable platform for medical technologists to exchange technical knowledge and troubleshooting experiences, which I believe is essential for advancing laboratory testing standards.

Q4. What are your field of interests in biomedical laboratory medicine?

My interest lies in advanced laboratory quality control (QC) and the clinical application of mass spectrometry.
During my Master's studies, I focused on quality assurance and biomarker validation. In daily practice, generating accurate and reproducible laboratory data is paramount. Therefore, I want to further study advanced QC models, such as real-time quality assurance program based on patient data (e.g., moving averages), to ensure the highest standards of data reliability.
Given the complexities of LC-MS/MS platforms, my interest is to find practical ways to apply these advanced QC protocols to minimize errors and establish a reliable routine testing environment.

Q5. What are your future goals?

My goal is to continuously deepen my practical expertise in mass spectrometry and laboratory quality assurance. To build a stronger theoretical foundation for this work, I hope to explore opportunities for advanced academic studies if the opportunity arises. My interest lies in studying how to solve everyday practical problems in the laboratory, such as matrix effects and the optimization of QC protocols for specialized chemistry.
Additionally, as part of the KSCLC, I look forward to maintaining open communication with medical technologists and laboratory societies across the Asia-Pacific region. By sharing operational methods and practical experiences, I want to help establish consistent, high-quality testing standards across laboratories.

Interviewer:

Dr. Ryunosuke Ohkawa (JSCC, Japan)

Professor, Department of Clinical Bioanalysis and Molecular Biology, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Japan
Member APFCB C-C

YOUNG SCIENTIST INTERVIEW

Akira Yoshimoto

Assistant professor

Department of Clinical Bioanalysis and Molecular Biology, Faculty of Graduate School of Medical and Dental Sciences, Institute of Science Tokyo.

Q1. Please Introduce Yourself?

My name is Akira Yoshimoto. I was born and raised in Tokyo. After graduating from Tokyo Medical and Dental University (now the Institute of Science Tokyo), I obtained my national license as a clinical laboratory scientist and earned my PhD in Health Care Science. Subsequently, I spent six years at the University of Tokyo Hospital, where I gained extensive experience in various roles, including outpatient phlebotomy, clinical chemistry, immunology, and urinalysis. Currently, I serve as an Assistant Professor at the Institute of Science Tokyo, where I am dedicated to educating future laboratory scientists and conducting research in clinical laboratory medicine.

Q2. What is your main focus?

My primary research focus is the development of biomarkers for atherosclerosis. Atherosclerosis occurs when plaque builds up in the arterial walls, narrowing the vessels and leading to cardiovascular disease and stroke. A “silent” disease progresses without noticeable symptoms. In the human body, high-density lipoprotein (HDL) plays a crucial role in protecting against atherosclerosis. We are currently working to establish the anti-atherosclerotic function of HDL as a novel clinical biomarker.

Q3. What else is important to you?

Although I have transitioned from clinical practice to academia, I remain committed to contributing to the well-being of patients and clinical laboratory scientists. For example, if we could perform approximately 20 biochemical tests using only 1 μL of blood, it would significantly reduce the burden on both patients and healthcare providers. This technology opens up exciting possibilities, ranging from home diagnostics to medical support for future space missions. I am pursuing this research alongside my main theme.

Furthermore, I believe student education is vital for the future of laboratory medicine. Our students pursue diverse paths—some work in hospitals, others join pharmaceutical or clinical research organizations, and some pursue advanced degrees to stay in academia. I strive to provide practical training that reflects real-world clinical settings, encouraging students to think critically. My goal is for them not just to perform tests, but to analyze abnormal values from multiple perspectives and determine the appropriate next steps.

Q4. What are your interests in biomedical laboratory medicine?

In clinical chemistry, our fundamental duty is to report accurate numerical data. Consequently, I am deeply interested in high-precision measurement technologies. In Japan, there is a growing focus on analyzing reaction time-course data. Many Japanese laboratory scientists have reported cases where unexpected values occurred due to abnormal reactions in patient samples. I have previously published a paper and presented at conferences on how certain diabetes medications can interfere with urinary creatinine measurements. Currently, I am collaborating with a domestic company to develop software that can analyze reaction time-course data for all laboratory samples in real-time.

Q5. What are your future goals?

During a presentation at a domestic conference, I conducted a survey asking participants what they hoped for the future of clinical chemistry in ten years. Surprisingly, the most common response was the desire to work from home. While achieving remote work in the current clinical laboratory framework presents many challenges, imagining such a future is fascinating. If the technology for remote laboratory work is realized, it could expand the field to home medicine and even the space industry. While it may not be easy to achieve, my ultimate goal is to create innovative clinical laboratory solutions that excite people around the world.

Interviewer:

Dr. Ryunosuke Ohkawa (JSCC, Japan)

Professor, Department of Clinical Bioanalysis and Molecular Biology, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Japan

WorldLab 2026: Advancing Global and Asia-Pacific Corporate Partnerships

Prof. Ana-Maria Simundic

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Corporate Members have long recognized the diverse benefits of conference sponsorship and valued attendance at events led by the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). This includes brilliant and emerging opportunities this October at IFCC WorldLab New Delhi 2026.

Organized by the IFCC and in partnership with the Association of Clinical Biochemists of India (ACBI), this 27th International Congress of Clinical Chemistry and Laboratory Medicine will be held at India's largest International Convention and Exhibition Center (IICC). More than 1300 abstracts have been reviewed thus far from 75+ countries with strong participation across Africa, Europe, Middle East, Latin America and Asia.

As corporate representative to the Executive board, Tricia Ravalico, comments that the enthusiasm across leaders has never been stronger. Ana-Maria Šimundić, corporate representative on the IFCC Conference Organizing Committee shares that tremendous thought has been put into the planning of this event, reinforcing exceptional value awaits. Tricia and Ana-Maria invite all potential sponsors to participate and engage at this exceptional event. Discover and build partnerships that are focused on the future of healthcare, challenging traditional thinking and contributing to the next chapter of laboratory medicine.

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The exhibition floor provides visibility into technologies, product launches, strategic priorities, and market direction.

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Corporate scientists and medical affairs professionals gain education on evolving standards, regulations, quality initiatives, and clinical applications that can inform business strategy.

Important Events during WorldLab 2026

Multiple events are planned during WorldLab 2026 for which corporate members can attend. Two stand-out sessions worth reminding all corporate members about are noted with times and dates below:

- October 25th, 2026. **IFCC Council Meeting** (09.00-13.00 Delhi local time)
- October 25th, 2026. **Executive Board Meeting with IFCC Corporate Members** (14.00-16.00 Delhi local time)

We are excited for next steps and hope to see everyone in New Delhi this October.

Respectfully,
Ana-Maria Šimundić and Tricia Ravalico

Maintaining and Improving Sigma Performance on VITROS 5600: A Positive QC Story from Yashoda Hospitals, Secunderabad

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Abstract

Background: Sigma metrics (σ) guide risk-based quality control (QC) by integrating bias, imprecision and TEa. We summarize how two analyzers maintained their Sigma bands over time and where analytes moved up a band, following targeted QC interventions.
Methods: Average σ was compiled at QC levels (L1/L2/L3 wherever is applicable) and categorized into >6 sigma,>5 to<6 sigma, >4 to <5 sigma, >3 to <4 sigma &<3 sigma. Total allowable error (TEa) was primarily based on CLIA 2024 criteria; for analytes without CLIA 2024 limits, where absent, RICOS, CAP, or RCPA limits were used. Bias was sourced from BIO-RAD EQAS, while imprecision; (CV%) was derived from internal quality control (IQC) data. A total of 38 analytes were evaluated on the primary analyzer while 20 analytes were assessed on the backup analyzer.
Results: Instrument 56004237 (primary) showed an increased share of assays in >5 σ for Clinical Chemistry (50.0%→73.1%). Instrument 56000582 (backup) showed improved >5 σ share in Immunoassay (57.1%→71.4%), with Prolactin moving up into ≥5 σ while other analytes maintained high bands.
Conclusions: Enhanced QC preparation/handling/storage, calibration, and lot management supported maintenance within bands sustained Sigma performance and band-up improvements without emphasizing declines.

Introduction

Sigma metrics (σ) have become an essential tool in laboratory medicine for assessing analytical performance by integrating total allowable error (TEa), bias, and imprecision into a single measurable index. This unified approach facilitates the implementation of risk-based quality control strategies in accordance with CLSI C24 guidelines, enabling laboratories to optimize quality practices based on assay performance. Increasingly, the focus has shifted from merely identifying underperforming assays to demonstrating sustained performance and achieving continuous improvement. Emphasis on maintaining high sigma performance reflects robust laboratory quality systems and operational consistency. In this study, we evaluated sigma performance of two VITROS 5600 analyzers over defined periods in 2023 and 2024, with particular focus on stability across sigma bands and identification of analytes that demonstrated measurable improvement following targeted quality control interventions.

Methodology

The study was conducted at the Department of Biochemistry, Yashoda Hospitals, Secunderabad. Analytical performance was evaluated using two VITROS 5600 analyzers, comprising a primary system (serial number 56004237) and a backup system (serial number 56000582). The analysis was conducted over two time periods: January–December 2023 and January–June 2024.Internal Quality Control (IQC) data from three levels (L1, L2, and L3) were used to determine imprecision (CV%) for each analyte, while Bias (%) was obtained from the BIO-RAD EQAS program. These parameters were used to calculate sigma (σ) for each analyte using the formula σ = (TEa − Bias) / CV. The average sigma value was derived by combining results across all IQC levels (L1, L2, and L3) and reporting the mean sigma per analyte. Sigma performance was classified into standardized categories as follows: >6 (world-class), 5–6 (excellent), 4–5 (good), 3–4 (acceptable), and <3 (poor).

A hierarchical approach was adopted for selecting Total Allowable Error (TEa). CLIA 2024 was used as the primary reference for routine chemistry and immunoassay parameters. For analytes where CLIA limits were unavailable, TEa was derived from biological variation data (RICOS database). In cases where both CLIA and RICOS limits were not available, alternative guidelines such as CAP and RCPA were used based on applicability and availability. For example, TEa for Vitamin D was adopted from CAP due to the absence of defined limits in CLIA and biological variation sources, while Free T3 was aligned with RCPA recommendations. This approach ensured consistent and clinically relevant TEa selection across all analytes.

Table 1. Analytical goals and calculation sources

Parameter	Description
Primary TEa source	**CLIA 2024**
Supplemental TEa sources	**Biological Variation (RICOS), CAP, RCPA**
Bias	**BIO-RAD EQAS program**
Precision (CV%)	**Internal Quality Control (IQC)**
Sigma calculation	**σ = (TEa − Bias) / CV**
Sigma classification	**>6 (World-class), 5–6 (Excellent), 4–5 (Good), 3–4 (Acceptable), <3 (Poor)**

TEa Guideline	Parameters
CLIA 2024	**Cholesterol (Total), HDL-C, Triglycerides, Bilirubin (Total), ALP, AST, ALT, Total Protein, Albumin, Glucose, Creatinine, Urea, Uric Acid, Calcium, Phosphorus, Amylase, Creatine Kinase, LDH, Iron, Magnesium, Direct LDL-C, TIBC, Vitamin B12, Folate, Ferritin, Total β-hCG, Total T3, Total T4, TSH, CEA, Cortisol, Free T4, tPSA, Troponin I ES, Intact PTH**
RICOS (Biological Variation)	**Bilirubin (Conjugated), Lipase, Microalbumin, Homocysteine, Insulin**
CAP	**Vitamin D (Total)**
RCPA	**Free T3**

Results

A total of 38 analytes were evaluated on the primary analyzer (VITROS 5600, serial number 56004237), while 20 analytes were assessed on the backup analyzer (VITROS 5600, serial number 56000582).

Primary System (56004237)

The sigma distribution for 2023 and 2024 is presented in Figure 1. An improvement in higher sigma categories was observed over time. The proportion of analytes in the >6 sigma category increased from 31.6% (12/38) in 2023 to 36.8% (14/38) in 2024. Similarly, the >5 sigma category increased from 18.4% to 23.7%.

While the proportion of analytes in the 4–5 sigma category remained stable (~21%), a reduction was noted in the 3–4 sigma category (28.9% to 15.8%), indicating upward movement into higher sigma bands. A small proportion of analytes (2.6%) shifted into the <3 sigma category in 2024.

A detailed analyte-wise distribution across sigma categories is shown in Figure 1. Notably, several parameters analytes demonstrated upward migration into higher sigma bands in 2024, particularly within the >6 and 5–6 sigma categories.

Backup System (56000582)

The sigma distribution for the backup analyzer is shown in Figure 2. For a total of 20 analytes, the >6 sigma category improved from 30% (6/20) in 2023 to 35% (7/20) in 2024, while the >5 sigma category remained stable at 15%.

A reduction was observed in the 4–5 sigma category (35% to 25%), with corresponding redistribution into higher performance categories. The 3–4 sigma category remained unchanged at 20%, while a single analyte (5%) was noted in the <3 sigma category in 2024.
The analyte-level distribution indicates overall stability with selective improvement in high-performing assays.

Summary of High Sigma Performance (>5 Sigma)

The proportion of assays achieving >5 sigma performance across instruments and assay types is summarized in Table 43.
For the primary system (56004237), clinical chemistry assays showed a significant improvement in >5 sigma performance, increasing from 50.0% in 2023 to 73.1% in 2024, while immunoassay performance remained stable (40% vs 38%).
For the backup system (56000582), clinical chemistry performance remained unchanged at 43%, whereas immunoassay assays demonstrated a notable increase from 57% to 71%.
Overall, the results demonstrate maintenance of sigma performance with selective upward shifts into higher sigma categories across both systems, reflecting improved analytical quality over the study period.

Table 2. Instrument 56004237 – Sigma distribution 2023 vs 2024

Sigma Rating	Total Assay-2023	No of parameter	2023 Sigma Score		Total Assay-2024	No of parameter	2024 Sigma Score
>6 Sigma	38	12	31.6%		38	14	36.8%
>5 Sigma		7	18.4%			9	23.7%
>4 Sigma		8	21.1%			8	21%
>3 Sigma		11	28.9			6	15.8%
<3 Sigma		0	0%			1	2.6%

Table 2a. Instrument 56004237 – Sigma distribution 2023 vs 2024

Sigma Score	Parameters – 2023	Parameters – 2024
> 6 Sigma	HDL-C, TG, Total bilirubin, ALP, Uric acid, Amylase, Lipase, Magnesium, Direct LDL-C, Microalbumin, Total T3, tPSA	TG, Total bilirubin, ALT, Uric acid, Phosphorus, Amylase, Lipase, LDH, Direct LDL-C, Direct TIBC, Microalbumin, Vitamin B12, Troponin I ES, tPSA
> 5 to < 6 Sigma	ALT, CK, LDH, Total β-hCG, TSH, Free T4, Vitamin B12	HDL-C, ALP, AST, Glucose, Calcium, CK, Magnesium, TSH, Insulin
> 4 to < 5 Sigma	AST, Glucose, Creatinine, Urea, Calcium, Phosphorus, Iron (total), Ferritin	Cholesterol (total), Total protein, Urea, Ferritin, Folate, CEA, Cortisol, Free T3
> 3 to < 4 Sigma	Cholesterol (total), Bilirubin (conjugated), Total protein, Albumin, Homocysteine, Folate, Vitamin D, CEA, Cortisol, Free T3, Total T4	Bilirubin (conjugated), Albumin, Creatinine, Total T4, Free T4, Intact PTH
< 3 Sigma	—	Iron (total), Vitamin D

Figure 1. Instrument 56004237 – Sigma distribution 2023 vs 2024

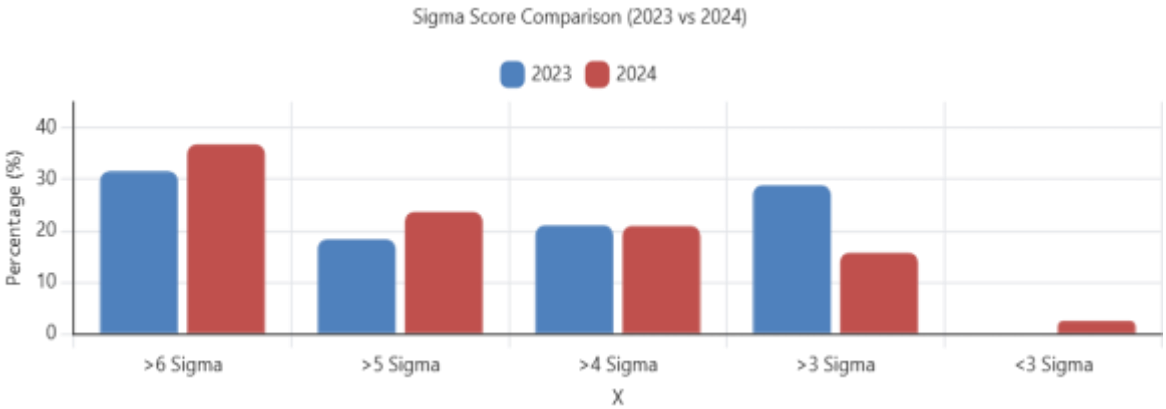

Table 3. Instrument 56000582 – Sigma distribution for 2023 vs 2024

Sigma Rating	Total Assay-2023	No of parameter	2023 Sigma Score (%)		Total Assay-2024	No of parameter	2024 Sigma Score (%)
>6 Sigma	20	6	30%		20	7	35%
>5 Sigma		3	15%			3	15%
>4 Sigma		7	35%			5	25%
>3 Sigma		4	20%			4	20%
<3 Sigma			0%			1	5%

Table 32a. Instrument 56000582 – Sigma distribution for 2023 vs 2024

Sigma Score	Parameters – 2023	Parameters – 2024
≥ 6 Sigma	HDL-C, Triglycerides, ALT, Direct LDL-C, FSH, CA-19.9	Triglycerides, Total bilirubin, ALT, Direct LDL-C, FSH, Testosterone, CA-19.9
≥ 5 to < 6 Sigma	Total bilirubin, Testosterone, Troponin I ES	Alkaline phosphatase, Prolactin, Troponin I ES
≥ 4 to < 5 Sigma	Cholesterol (total), ALP, AST, Glucose, Creatinine, Prolactin, CA-125	Cholesterol (total), AST, Glucose, LH, CA-125
≥ 3 to < 4 Sigma	Total protein, Albumin, Urea, LH	Total protein, Albumin, Creatinine, Urea
< 3 Sigma	—	Bilirubin (conjugated)

Figure 2. Instrument 56000582 – Sigma distribution for 2023 vs 2024

Table 43. Summary of assays in Sigma Score excellent (>5 Sigma)

Instrument	Assay	2023 >5 Sigma (%)	2024 >5 Sigma (%)
56004237	Clinical Chemistry	50.0	73.1
56004237	Immunoassay	40.0	38
56000582	Clinical Chemistry	43	43
56000582	Immunoassay	57	71

Discussion

The present study highlights the effective application of sigma metrics in monitoring and improving analytical quality in a routine clinical laboratory setting. The observed improvement in higher sigma categories (>5 sigma), particularly across both analyzers between 2023 and 2024, reflects the impact of structured quality control interventions, including optimized IQC practices, calibration strategies, and reagent lot management. The adoption of a hierarchical TEa selection approach—utilizing CLIA as the primary reference, supplemented by biological variation (RICOS), CAP, and RCPA guidelines—ensured comprehensive and analyte-specific performance evaluation. Standardized sigma classification enabled risk-based quality control implementation in accordance with CLSI C24 recommendations, allowing efficient resource utilization while maintaining analytical reliability. Importantly, the study emphasizes sustained performance and targeted improvements rather than isolated deficiencies, demonstrating that disciplined quality processes can effectively enhance laboratory performance without increasing operational burden.

Conclusion

Across two VITROS 5600 instruments, Sigma performance was maintained year-over-year with visible improvements into the >5 Sigma band. The sustained quality profile demonstrates practical gains achievable through disciplined QC processes without focusing on declines. The sustained quality profile highlights the practical value of disciplined QC processes in maintaining high analytical performance while achieving improvements in selected analyses.

Author Contributions

All authors contributed substantially to the study design, data collection, analysis, and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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Expert Interview: Building Sustainable Medical Laboratories: Balancing Environmental Responsibility, Quality, and Innovation

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Introduction

Every laboratory has a responsibility that extends beyond delivering accurate test results—it must also protect the resources for future generations. Sustainable laboratory practice is about making smarter choices every day e.g, reducing waste, conserving energy, optimizing testing processes, and embracing innovations that improve efficiency without compromising patient care. True sustainability also includes supporting laboratory professionals, maintaining financial viability, and ensuring equitable access to quality diagnostics. Truly, by embedding sustainability into routine operations and decision-making, laboratories can contribute to better healthcare outcomes while minimizing their environmental impact. Thus, creating a healthier future for patients, communities, and the planet.

QUESTIONS:

Q1. Can healthcare ever be truly sustainable while laboratory testing volumes continue to increase globally?

Prof. Tomris Ozben

Healthcare can become sustainable despite increasing laboratory testing volumes, provided that growth is accompanied by greater efficiency, innovation, and responsible resource management. Sustainability does not require reducing access to diagnostics; rather, it requires ensuring that testing is appropriate, resources are used efficiently, and environmental impacts are minimized while maintaining high-quality patient care.Laboratory medicine plays a critical role in sustainable healthcare. A key priority is optimizing test utilization by reducing unnecessary and duplicate testing, which lowers reagent consumption, hazardous chemical use, waste generation, and healthcare costs. The World Health Organization's Essential In Vitro Diagnostics (IVD) List supports this approach by identifying high-value diagnostic tests for common diseases and infectious disease management.

Additional strategies include improving energy efficiency, reducing water consumption, minimizing plastic and hazardous waste, adopting automation and digital technologies, and promoting sustainable procurement practices.
Emerging technologies such as artificial intelligence can further enhance efficiency and resource utilization.Ultimately, sustainable healthcare is achievable if laboratories focus on delivering high-value diagnostics while continuously improving environmental, economic, and operational performance. In this way, laboratory medicine can support both better patient outcomes and a more sustainable healthcare system.

Dr. Tony Badrick

Yes, not only can we, but we have no choice. Increasing volumes make an already bad situation worse but also make the issue more obvious. Thus, more labs and governments will see that we are a part of the problem. Indeed, the more waste we produce, the more we ourselves impact on the health of individuals. The solution is not difficult for a profession that is health care minded and understands how to improve.

Dr. Tjan Sian

Sustainability is a collaborative effort to meet current requirements without depriving future generations. In the current laboratory practice, there are still a lot of non-value added processes, inefficiencies, non-energy friendly practices, and high volume of waste. With increased awareness of the healthcare system for sustainability practice, more targeted and personalised tests, more environment friendly equipment and methods, digitalization and efficient lab practice, studies have shown great reduction in carbon footprint and energy utilization can be achieved even with increased laboratory testing volumes. The inclusion of environment protection in accreditation requirements also supports sustainable environment friendly laboratory practice.

Q2. Should laboratories prioritize carbon reduction targets even when sustainability measures increase operational costs?

Prof. Tomris Ozben

Yes, laboratories should prioritize carbon reduction targets even when sustainability measures increase short-term operational costs, because these investments often generate long-term environmental, economic, and operational benefits. However, implementation must be balanced with patient safety, diagnostic quality, and financial sustainability. Several challenges can slow progress. Upfront investments in energy-efficient equipment and infrastructure may be substantial, particularly in resource-constrained healthcare systems. Workforce training requirements, cultural resistance to change, and regulatory or accreditation constraints can also limit flexibility in adopting greener practices. Despite these barriers, strong leadership and institutional commitment are essential. Clear sustainability strategies, measurable goals, and pilot projects can demonstrate feasibility,

build confidence, and support gradual implementation. Sustainable practices often improve operational efficiency, reduce waste, lower energy consumption, and enhance organizational resilience over time. Carbon reduction should therefore remain a strategic priority. Success depends on a structured and evidence-based approach that addresses financial, regulatory, and cultural challenges while maintaining the high standards of quality and patient care expected from modern laboratory services.

Dr. Tony Badrick

There are many ways to measure the environmental impact of medical laboratories, all related to waste. Measuring greenhouse gas emissions is standard, though difficult to calculate. Just reducing the use of water, electricity and solid waste (plastic, paper, clinical) is critical and easy to measure. It is not true that sustainability measures increase costs. Sustainability is about reducing waste, which must reduce cost. Reducing error in an assay reduces waste as well. It reduces laboratory staff, patient and clinician time, and reagent use. This is the cost of error. Similarly, reducing waste in operations reduces the cost of a laboratory.

Dr. Tjan Sian Hwa

Sustainability initiative calculation should not only be based on short term cost efficiency but also long-term operational cost efficiency. A broader benefit of carbon reduction toward quality in laboratory service, staff safety, mankind and environment should also be considered. Sustainability initiatives should cover not only environmental protection, but also consider social equity, and economic viability. Like all programs, a risk management evaluation should be done and should be balanced with the available resources in each laboratory. There are still many inefficiencies in laboratory processes, and a thorough process mapping can give other carbon reduction initiatives to be considered.

Q3. Who bears the greatest responsibility for laboratory sustainability—the laboratory, manufacturers, regulators, or healthcare systems?

Prof. Tomris Ozben

Laboratory sustainability is a shared responsibility. Laboratories can optimize daily operations and resource utilization, manufacturers can develop more sustainable instruments, reagents, and consumables, regulators can establish supportive policies and standards, and healthcare systems can create incentives for sustainable procurement and environmentally responsible practices. While laboratories play a central role because they directly manage testing processes, meaningful progress cannot be achieved by laboratories alone. Many sustainability challenges, such as excessive packaging, single-use plastics, energy-intensive equipment, and supply-chain emissions, require action from manufacturers and healthcare organizations. Similarly, regulators can accelerate progress by integrating sustainability considerations into accreditation standards and procurement frameworks. Collaboration among healthcare professionals, industry partners, policymakers, environmental experts, and laboratory leaders is essential to develop practical, evidence-based solutions that balance environmental goals with quality, safety, patient care, and financial sustainability. Sustainable laboratory medicine will advance most effectively when all stakeholders accept shared responsibility and work together to implement coordinated, measurable actions that reduce environmental impact while maintaining excellence in patient care.

Dr. Tony Badrick

Everyone is responsible, but at different levels, based on the responsibilities. It's the same question we could ask about global responsibility? 'Who has the greatest responsibility for global sustainability? It is every one of us. We should all practice reduce, reuse, and recycle. We all need to act appropriately in the lab, switching off unused equipment and lights, not mixing different waste streams, and not wasting paper. Managers need to lead sustainability in the lab and consider what manufacturers provide the most sustainable products. Regulators should ensure laboratories follow best practice for sustainable operations. Eventually, governments will mandate that all parts of the healthcare system implement sustainable practices.

Dr. Tjan Sian Hwa

It is an inter linked process that is initiated with awareness of each stakes-holder. Regulation, national program and endorsement by the government will be an anchor for an effective laboratory sustainability. Healthcare policies that integrate sustainability requirements and risk management

in each activity, including in the selection of a new procedure, test and instrument, will guide and control laboratory sustainability. Technology advancement and innovation in sustainability is a key element in the implementation. And successful laboratory sustainability indeed is depended on laboratory management and staff commitment.

Q4. What is the biggest misconception currently limiting progress toward sustainable laboratory medicine?

Prof. Tomris Ozben

One of the biggest misconceptions is that sustainability and quality are competing priorities. Many healthcare professionals assume that environmentally sustainable practices inevitably compromise diagnostic accuracy, patient safety, or operational efficiency. In reality, sustainability and quality are often mutually reinforcing. Well-designed sustainability initiatives can improve laboratory performance while reducing environmental impact. Measures such as optimizing test utilization, reducing waste, improving energy efficiency, digitalizing workflows, and adopting innovative technologies can decrease resource consumption while maintaining or even enhancing quality, productivity, and patient outcomes.

Another misconception is that sustainability is primarily an environmental issue. In fact, sustainability encompasses environmental, economic, and social dimensions. Sustainable practices can reduce costs, strengthen operational resilience, improve resource management, and support long-term healthcare delivery. Rather than being viewed as an additional burden, sustainability should be recognized as an opportunity to improve efficiency, reduce waste, and create more resilient and responsible healthcare systems. The challenge is not choosing between quality and sustainability, but integrating both into routine laboratory practice.

Dr. Tony Badrick

That we have a choice about implementing sustainable management systems.

Dr. Tjan Sian Hwa

The biggest misconception that limits sustainability in laboratory medicine is the opinion that sustainability is the top management responsibility and requires expensive technology. In some places, staff initiatives and collaborative small efforts from each department result in an impactful sustainability result that drive further other sustainability practices

Q5. If you could change one aspect of current laboratory practice to improve sustainability worldwide, what would it be and why?

Prof. Tomris Ozben

If I could change one aspect of current laboratory practice to improve sustainability worldwide, I would focus on improving test appropriateness and reducing unnecessary laboratory testing. A significant proportion of tests performed globally provide limited clinical value, contributing to waste, increased healthcare costs, and avoidable environmental impacts. Promoting evidence-based test ordering through clinician education, laboratory stewardship programs, clinical decision-support systems, and closer collaboration between laboratory professionals and clinicians would improve patient care while reducing unnecessary resource consumption. Fewer inappropriate tests would mean lower use of reagents, consumables, energy, water, and transportation resources, while also decreasing waste generation. Looking ahead, artificial intelligence and digital technologies have the potential to further optimize test utilization, streamline workflows, and improve operational efficiency. Combined with process optimization and sustainable diagnostic innovations, these advances can help laboratories deliver high-quality care with a smaller environmental footprint. Improving test appropriateness represents one of the most effective and immediately achievable strategies to enhance the sustainability of laboratory medicine worldwide.

Dr. Tony Badrick

Mandate ISO 14001 for all laboratories.

Dr. Tjan Sian Hwa

With the availability of Internet of Things, healthcare information system, cloud system, and other information technology advancements, optimization in digitalization and artificial intelligence capability is a great opportunity to improve sustainability using the available resources.

Digitalization can minimize paper consumption, reduce patient and staff mobility, automate instrument and electricity usage, and optimize logistics. Artificial intelligence and machine learning used in laboratories can support long distance virtual diagnostics, hence reducing carbon footprint. Integration of health information data in a hospital or national-wide will improve effective use of laboratory results and reduce retesting.

Conclusion: Despite broad consensus that sustainability must become integral to laboratory medicine, translating this ambition into everyday practice remains difficult. A central gap is the lack of standardized indicators for measuring and benchmarking environmental performance across laboratories. Sustainability criteria are also inconsistently reflected in accreditation frameworks, procurement policies, and healthcare regulations worldwide. For laboratories in resource-limited settings, financial and infrastructure constraints often slow the adoption of greener technologies and digital solutions, widening the gap between intent and implementation. Perhaps most importantly, sustainability needs to be reframed as a collective responsibility, embraced at every level of laboratory practice, rather than treated as a top-down management directive. Closer collaboration between laboratories, manufacturers, regulators, and professional bodies will be key to driving innovation, curbing unnecessary testing and waste, and building the evidence base showing that sustainable practices strengthen not just environmental outcomes, but efficiency, quality, and the long-term resilience of healthcare systems.

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A distinguished academic and laboratory medicine leader, Prof. Özben has held senior positions at Akdeniz University, including Vice Rector, Director of the Central Laboratory, and Chair of the Department of Medical Biochemistry. Her research focuses on cancer biomarkers, liquid biopsy, diagnostic and prognostic markers, laboratory automation, and quality management. She has published more than 300 scientific papers, edited several books, serves on the editorial boards of international journals, and has delivered over 500 invited lectures and keynote presentations worldwide.

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Integrating Risk Management into Medical Laboratory Quality Systems: ISO 15189:2022 Perspectives

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Risk management has become a fundamental component of quality management systems in medical laboratories seeking accreditation according to ISO 15189:2022. The standard, ISO 15189: Medical Laboratories – Requirements for Quality and Competence, emphasizes a risk-based approach to ensure the reliability of laboratory results, patient safety, and continuous improvement of laboratory processes. The standard complements ISO 15189:2022 by focusing specifically on the prevention of patient harm through systematic risk management practices.

Risk management is not limited to technical procedures but extends to personnel competence, equipment performance, information systems, environmental conditions, and organizational processes. Effective risk management enables laboratories to identify potential hazards, assess their impact, implement preventive measures, and monitor the effectiveness of controls.

As laboratory results significantly influence clinical decision-making, errors within laboratory processes can lead to adverse patient outcomes, delayed diagnoses, inappropriate treatments, and increased healthcare costs. **ISO 22367:2026**, Medical Laboratories—Application of Risk Management to Medical Laboratories, provides a structured framework for identifying, evaluating, controlling, and monitoring risks associated with laboratory services.

Historically, laboratories focused primarily on quality control measures designed to detect errors after they occurred. Modern quality management systems, however, emphasize a proactive approach in which potential failures are identified and addressed before they result in harm. Rather than waiting for incidents to occur, laboratories are encouraged to anticipate potential failures and implement preventive measures. This proactive approach reduces the likelihood of adverse events and minimizes disruptions to laboratory operations.

The main objectives of risk management in medical laboratories include:

1. Ensuring patient safety.
2. Maintaining the accuracy and reliability of test results.
3. Reducing the occurrence of laboratory errors.
4. Improving operational efficiency.
5. Supporting continual improvement.
6. Demonstrating compliance with accreditation requirements.

Fig 1. Risk Monitoring Framework

Risk identification is the process of recognizing potential hazards that could compromise laboratory quality or patient safety. Risks may originate from technical, organizational, environmental, or human factors. Risk identification methods may include process mapping, incident reporting systems, audits, staff interviews, customer complaints, and failure mode analysis.

The pre-examination phase is recognized as one of the most error-prone stages of laboratory testing including patient preparation, specimen collection, labeling, transportation, and specimen reception.

Common risks include:

- Incorrect patient identification.
- Improper specimen collection techniques.
- Inadequate sample labeling.
- Insufficient sample volume.
- Improper storage conditions.
- Transportation delays.

The examination phase includes all analytical activities performed within the laboratory.

Potential risks include:

- Equipment breakdown and malfunction.
- Calibration errors.
- Reagent contamination.
- Analytical errors
- Inadequate quality control procedures.

Risk controls often involve preventive maintenance, calibration programs, internal quality control procedures, proficiency testing, and validation of analytical methods.

The post-examination phase includes result review, interpretation, reporting, and communication with healthcare professionals.

Risks may include:

- Incorrect result transcription.
- Delayed reporting of critical values.
- Information system failures.
- Unauthorized access to patient records.
- Misinterpretation of laboratory data.
- Inadequate staff competency.

Risk Analysis. Once hazards have been identified, laboratories must determine the likelihood of occurrence and the potential consequences associated with each risk.

Risk analysis considers factors such as:

- Frequency of occurrence.
- Severity of potential harm.
- Ability to detect failures before harm occurs.
- Existing control measures.

Fig 2. Risk Matrix (Probability × Severity)

RISK MATRIX **(Probability ×Severity)**	**Low**	**Medium**	**High**
Minor	Low	Low	Medium
Moderate	Low	Medium	High
Severe	Medium	High	Critical

This analysis helps laboratories understand which risks require immediate attention and which may be considered acceptable. Many laboratories use a risk matrix to prioritize risks according to their probability and impact. Risks classified as high priority require immediate action, while lower-priority risks may be monitored through routine quality activities.

A common method is Failure Mode and Effects Analysis (FMEA), which evaluates potential failure modes and assigns scores for severity, occurrence, and detection. For example, mislabeling a patient specimen may have a high severity score because it can result in incorrect diagnosis and treatment. Therefore, the laboratory must implement strong identification controls to reduce this risk.

Risk evaluation involves comparing analyzed risks against predefined acceptance criteria. Laboratories must determine whether the level of risk is acceptable or whether additional controls are required. After assessing risks, laboratories must establish measures to eliminate or reduce them to acceptable levels. Risk assessments should be documented and periodically reviewed to ensure they remain relevant as laboratory processes evolve.

Methods for monitoring risks include:

- Internal audits.
- Management reviews.
- Quality indicators (e.g. specimen rejection rates, turnaround times)
- Incident reporting systems.
- Customer feedback.
- Proficiency testing results.

Risk management is a central requirement of ISO 15189 and an essential component of laboratory quality management systems. Through systematic identification, assessment, control, and monitoring of risks, medical laboratories can protect patient safety, improve service quality, and ensure reliable testing outcomes. Effective risk management encompasses all laboratory activities, from specimen collection to result reporting, and requires active participation from both leadership and staff. By integrating risk-based thinking into daily operations, laboratories not only achieve compliance with accreditation requirements but also foster a culture of continual improvement and excellence.

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The gold standard under the microscope: navigating HbA1c standardisation and discrepancies

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Introduction

Diabetes is no longer just a medical concern; it is a major global health crisis [1]. Cases are projected to reach 853 million by 2050, with the vast majority living in low- and middle-income communities, representing a massive shift in global demographics and disease burden [2]. For these patients, the impact is deeply personal. Undiagnosed or misdiagnosed diabetes leads to devastating complications such as retinopathy, loss of vision and amputations that could have been prevented.

At the heart of this diagnostic journey sits a single, critical marker - Haemoglobin A1c (HbA1c). For decades, it has been the cornerstone of diabetes management and since 2011 also advocated by the WHO for the diagnosis of diabetes at a value of 48mmol/mol (6.5%), in line with American Diabetes Association (ADA) recommendations [3].

HbA1c is formed by the non-enzymatic binding of glucose to haemoglobin and reflects average blood glucose levels over approximately 3 months, particularly the preceding 30–60 days. Major studies, including the Diabetes Control and Complications Trial (DCCT) and the United Kingdom Prospective Diabetes Study (UKPDS), demonstrated that lower HbA1c levels are associated with reduced risk of diabetes-related microvascular and macrovascular complications [4,5]. Despite its widespread use, analytical variation remains a silent disruptor in clinical care. Without rigorous standardisation, not all HbA1c results mean the same thing. This translates to real consequences: patients could be told they are living with diabetes when they are not, or worse, have a diagnosis missed entirely.

Despite its widespread use, analytical variation remains a silent disruptor in clinical care. Without rigorous standardisation, not all HbA1c results mean the same thing. This translates to real consequences: patients could be told they are living with diabetes when they are not, or worse, have a diagnosis missed entirely.

Beside analytical variation there is also the non-glycaemic biological variation of HbA1c. It refers to differences in HbA1c levels that occur independently of blood glucose concentrations. While HbA1c is primarily used as an indicator of average glycemia over the previous 2–3 months, several biological factors can influence its value without reflecting true changes in glucose control. These factors include variations in red blood cell lifespan, age, ethnicity, genetic traits, anemia, hemoglobin variants, and certain medical conditions. Understanding non-glycemic biological variation is important because it can lead to HbA1c values that either overestimate or underestimate an individual's actual glycemic status, potentially affecting the diagnosis and management of diabetes.

Specifically, research into non-glycaemic biological variation of HbA1c reveals a sobering reality: even if a laboratory achieves perfect analytical performance, with zero bias and zero imprecision, the inherent biological variation among individuals means that the risk of misclassification remains as high as 11% [6]. This highlights the importance of considering the full clinical picture when making a diagnosis, rather than relying on a single parameter.

This article explores how the global medical community is moving from chaos in HbA1c results to global standardisation, how nations like Thailand are embracing quality assurance, and what clinicians must do when the laboratory result doesn't match the clinical picture.

Speaking the same language: the evolution of standardization

Historically, if a patient had their blood drawn in two different laboratories, the results could vary significantly. The inter-laboratory coefficients of variation (CV), a statistical measure of precision, frequently exceeded 15-20%. In practice, a patient whose results showed good control at one hospital could be flagged as "high-risk" at another.

The International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) represents true scientific standardisation. It defines the analyte with absolute precision: glucose attached to the N-terminal valine of the haemoglobin beta chain. The IFCC system is traceable to a primary reference method using pure A1c and A0 (non-glycated haemoglobin) as a standard [7]. It provides the "scientific truth" and the metrological foundation that ensures a test measures exactly what it claims to measure.

To understand the current state of diabetes diagnostics, we must look back at the initial absence of a global standard. Before the IFCC standard, there were no pure calibrators and no primary reference method, meaning laboratories operated in a landscape of testing where results were often incomparable.

The National Glycohaemoglobin Standardization Program (NGSP) chose a pragmatic path of harmonisation. They decided to align all methods to the specific testing method used in the landmark DCCT and UKPDS studies [3,4].

This was a vital move to ensure that patient results could be linked to the known risks of long-term complications, even before a true metrological system existed.

Today, these two systems do not compete; they co-exist through a necessary compromise. To ensure global consistency, a master equation was established to link the NGSP's clinical harmonisation with the IFCC's scientific standardisation [8].

The workflow that maintains this alignment is complex but vital. It moves from the patient's sample up to the clinical laboratory, then to manufacturers, and finally to reference laboratories. While regions like the United States prefer NGSP units (%) for their familiarity, and others prefer IFCC units (mmol/mol), the underlying standardisation ensures that these units are mathematically convertible and scientifically valid [9].

Today, thanks to a concerted international effort of the NGSP and the IFCC, the variability of HbA1c between different HbA1c methods has dropped to around 3.5% [10].

The Role of External Quality Assurance

While standardisation is the responsibility of manufacturers, ensuring their instruments are calibrated to the IFCC primary reference method before they ever leave the factory, the laboratory's role is to verify that these instruments perform correctly in the real world. This is the domain of External Quality Assurance (EQA).

The purpose of an EQA scheme is effectively a global reality check. It ensures that the standardisation promised by manufacturers holds true in clinical practice. Fundamentally, EQA asks: does a blood sample tested in Bangkok yield the same result as one tested in London? Without this independent verification, local variables can lead to inconsistencies that compromise patient care.

Thailand offers a compelling case study on how a nation can implement EQA to check the analytical performance of different HbA1c methods. Recognising that inconsistencies among Thai laboratories were threatening the accuracy of diabetes monitoring, the Department of Medical Sciences launched the National External Quality Assurance (EQA) Haemoglobin A1c Programme in 2016 [11].

This intervention was distinct in its design. Unlike some EQA schemes that rely on processed samples, the Thai model collaborated with major university hospitals such as Ramathibodi and Siriraj and a certified IFCC and NGSP reference laboratory to implement an accuracy-based programme using fresh blood panels. Fresh whole blood has a greater commutability than lyophilized material. Although lyophilized material has the advance of longer stability, the differences observed between analytical methods with fresh whole blood are more likely to reflect true methodological differences rather than artifact introduced by sample processing like lyophilization It was innovative because it was accuracy-based, with values assigned using four IFCC and NGSP secondary reference measurement procedures. In many EQA schemes, results are compared only with those of laboratories using the same analytical method, without establishing whether the reported values are actually correct or accurate. This approach, in contrast, enabled the assessment of true analytical accuracy rather than merely method-specific agreement.

The results of this program provided a clear view of the landscape. The data highlighted that while the bias (the difference between the average test result and the reference value) was often small, the overall CV (variability) remained high. This underscored that while labs were generally aiming at the right target, their precision needed tightening.

The future of this model is ambitious. It includes expanding the EQA network beyond major hubs to community hospitals and linking this data to a nationwide e-health system. This initiative aims to bridge the gap between rural and urban healthcare, ensuring that a patient receives a consistent high level of diabetes care regardless of where the participating labs are located.

Continuous Glucose Monitoring (CGM) and HbA1c: a more consistent and complete glycemic picture

A revolution in wearable technology, like CGM, has introduced a new variable for the lab and the clinician to reconcile.

These CGM devices offer a wealth of data that a single lab test cannot, specifically capturing real-time fluctuations and hypoglycemic trends. While an HbA1c result provides a three-month average, it can mask dangerous "lows" if they are balanced out by "highs." CGM fills this gap by recording the "time in range" and identifying patterns of hypoglycemia that require immediate clinical intervention [12].

A key metric generated by these devices is the Glucose Management Indicator (GMI). It is important to distinguish this from a real-time glucose reading. GMI is a derived number; it is an estimate of what a patient's HbA1c would likely be, calculated based on the average glucose values captured by the CGM over the previous 14 days [13].

However, clinicians are increasingly facing a confusing scenario where the patient's GMI says one thing, but the laboratory HbA1c result says another. Because the GMI is a "predicted A1c" based on a short two-week window of glucose data, while the lab-measured HbA1c is a physical measurement of glycated haemoglobin over three months, the two markers are frequently discordant.

Understanding this difference is critical: the lab-measured HbA1c remains the gold standard for long-term risk, but the CGM and its GMI offer the granular detail necessary to adjust daily therapy and catch the "hidden" lows that a laboratory test simply cannot see.

To resolve this discordance, one must understand that these two tools measure different aspects of biology.

- HbA1c is a weighted average of glucose levels over the past 3 months [3]. It is fundamentally tied to red blood cell (RBC) biology. It captures the overall glucose exposure but misses the peaks and valleys.
- GMI captures real-time trends, hypoglycaemic events, and variability [13]. However, it is calculated from glucose measured in interstitial fluid, not blood, and is subject to sensor lag and user-related factors (e.g., wear time, sensor adequately immobilised).

Authors of a recently published paper suggested that a difference of ≥ 0.8% (9 mmol/mol) between the GMI and the HbA1c is the threshold for clinical significance [14]. Smaller variations typically reflect normal biological and analytical differences. When values diverge significantly, systematic evaluation becomes essential, and clinicians must investigate.

Investigating discordance between GMI and HbA1c readings

The investigation requires a dual approach, checking both the technology and the biology:

- Sensor check: Was CGM sensor wear time sufficient to ensure reliable GMI estimation? Were there "compression lows" caused by sleeping on the sensor?
- Patient check: Are there conditions altering the lifespan of red blood cells? Is the patient anaemic? Is the patient pregnant? Is there a haemoglobin variant present?

Ultimately, GMI cannot replace HbA1c, but rather a complementary tool. HbA1c provides the validated average that guides diagnosis and major treatment decisions. CGM reveals patterns informing day-to-day management. When they align, confidence increases. When they diverge, investigation reveals important clinical information that neither measure alone would provide.

When the Laboratory is "Right" but the Result is "Wrong"

Even with analytical accurate HbA1c methods fully traceable to the IFCC primary reference method and accurate sensors, biological interference can lead to results that are analytically correct but clinically misleading. Two specific scenarios often arise that highlight the need for laboratory-informed care.

Scenario A: The Haemoglobin Variant

Genetic variants in haemoglobin, such as HbJ Baltimore, can dramatically affect HbA1c measurements. Depending on the assay method used (for example, High-Performance Liquid Chromatography (HPLC) versus Immunoassay), variants can produce falsely low or high HbA1c results [15].

- The Risk: A patient might be treated for diabetes they do not have, risking dangerous hypoglycaemia. Conversely, a diabetic patient might be left untreated because their HbA1c looks falsely normal.
- What to look out for: In these instances, the HbA1c is analytically correct but physiologically irrelevant. Alternative markers, such as Fructosamine, Glycated Albumin and or CGM data, become essential.

A commitment to laboratory-informed care

The journey to optimised diabetes care is not solely about better drugs or newer technology; it is about confidence in the numbers that guide our decisions. The transition from the era of poorly harmonized HbA1c testing to global standardization has been a triumph of scientific collaboration, but the work is not finished.

Laboratories must continue to commit to strategic method selection, choosing assays based not just on cost, but on interference patterns and manufacturer support. Mandatory participation for laboratories and users of point-of-care devices in accuracy-based EQA programmes is non-negotiable for maintaining accuracy.

For clinicians, the path forward involves a shift in perspective. A test result is not a verdict; it is a piece of data that must be interpreted within the context of the patient's unique physiology. By understanding the limitations of HbA1c, the nuances of GMI, and the potential for interference, healthcare professionals can ensure that every diagnosis is accurate and every treatment plan is safe. The synergy between robust standardisation and clinical awareness is the only way to ensure patient safety. The ultimate goal is simple yet profound: to ensure every HbA1c result is traceable, comparable, and clinically meaningful, driving reliable and equitable diabetes care worldwide.

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Hyperglycemia-Induced Oxidative Stress and Inflammatory Signaling in the Pathogenesis of Type 2 Diabetes Mellitus

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Abstract:

Insulin resistance arises from serine phosphorylation of insulin receptor substrate (IRS) proteins mediated by stress kinases such as c-Jun N-terminal kinase (JNK) and IκB kinase-β (IKKβ), compounded by lipotoxic and cytokine-driven signaling defects. Sustained hyperglycemia diverts glucose flux into four classical pathogenic pathways, the polyol pathway, advanced glycation end-product (AGE) formation, protein kinase C (PKC) activation, and hexosamine biosynthesis, each converging on excess reactive oxygen species (ROS) generation. ROS-mediated activation of NF-κB establishes a self-amplifying loop between oxidative stress and chronic low-grade inflammation, further impairing insulin signaling and accelerating vascular injury. Epigenetic changes underlying "metabolic memory" explain why complications may progress despite subsequent glycemic control. Oxidative stress and inflammation are not peripheral bystanders but central, mechanistically interdependent drivers of T2DM pathogenesis and its complications. Early, intensive metabolic control exploits a therapeutic window before metabolic memory is consolidated, underscoring the need for sensitive biomarkers and targeted antioxidant/anti-inflammatory strategies alongside conventional glycemic management.

Keywords: Type 2 diabetes mellitus; Insulin resistance; Oxidative stress; Reactive oxygen species; Advanced glycation end products; Metabolic memory

1. INTRODUCTION

Diabetes mellitus derives its name from the Greek diabētes ("to pass through") and the Latin mellitus ("honey-sweet"), a nomenclature that reflects centuries of clinical observation predating modern biochemical characterization.[1,2] What was once identified purely by its cardinal symptom, the passage of abnormally sweet urine, is now recognized as a heterogeneous group of metabolic disorders unified by chronic hyperglycemia but distinguished by markedly different underlying mechanisms. Contemporary classification distinguishes the heterogenous etiologies of diabetes mellitus , ranging from the autoimmune destruction of pancreatic β-cells and absolute insulin deficiency in type 1 diabetes mellitus (T1DM), driven by autoimmune destruction of pancreatic β-cells and absolute insulin deficiency, the progressive insulin resistance and eventual insulin secretory failure in from type 2 diabetes mellitus (T2DM), characterized by progressive peripheral insulin resistance coupled with relative, and eventually absolute, insulin secretory failure. to transient gGestational diabetes and monogenic forms such as maturity-onset diabetes of the young account for a smaller, though clinically important, proportion of the overall disease burden. This etiological heterogeneity has significant implications for pathophysiological research, as mechanisms established in one form of diabetes cannot be assumed to generalize to another.

The global burden of diabetes has risen sharply over the past three decades. Worldwide prevalence increased from approximately 200 million affected individuals in 1990 to 830 million in 2022,[3] while contemporary estimates from the International Diabetes Federation indicate that 589 million adults currently live with diagnosed diabetes, with a further 252 million remaining undiagnosed. An additional 635 million adults have impaired glucose tolerance and 488 million have impaired fasting glucose, placing this population at substantially elevated risk of progression to overt disease.[4] This rise has not been uniform: the steepest increases in both prevalence and undiagnosed disease burden have occurred in low- and middle-income countries, where healthcare systems are often least equipped to manage the resulting long-term complications, underscoring diabetes as a disease of profound global health inequity rather than merely a consequence of affluence.

Type 2 diabetes mellitus accounts for approximately 90% of all diabetes cases and is defined by chronic hyperglycemia resulting from progressive resistance to the peripheral actions of insulin. Although historically considered a disease of middle and later life, epidemiological data now document a marked shift toward earlier age of onset.[5] Its pathogenesis reflects the interaction of non-modifiable risk factors, advancing age, family history, gestational diabetes, and specific ethnic backgrounds; with modifiable determinants including central obesity, physical inactivity, and dietary patterns.[5] Importantly, T2DM is no longer understood as a disorder confined to the classical triad of liver, muscle, and pancreas; contemporary pathophysiological models implicate a broader constellation of tissues, including adipose tissue, the gastrointestinal tract, kidney, brain, and vascular endothelium, each contributing distinct defects in glucose homeostasis, incretin signalling, and inflammatory tone. This expanding, multi-organ view of T2DM pathogenesis has reframed the disease as a systemic metabolic-inflammatory disorder rather than a purely glycemic one, a perspective central to the mechanistic focus of this review.

The clinical and economic consequences of T2DM are considerable. Rapid urbanization and economic transition have driven a global rise in disease burden,[6] with uncontrolled hyperglycemia predisposing to both macrovascular complications (coronary artery disease, cerebrovascular disease, peripheral arterial disease) and microvascular complications (retinopathy, neuropathy, nephropathy). Notably, subclinical vascular injury is frequently already present at the time of diagnosis, reflecting a preceding asymptomatic hyperglycemic interval of several years,[7] and cardiovascular disease remains the leading cause of mortality in this population. Encouragingly, early and intensive multifactorial intervention has been shown to substantially reduce complication risk,[8] with benefits that persist for years beyond the intervention period, a phenomenon termed the "legacy effect."[9] The persistence of this benefit, and conversely the persistence of harm from early poor control, points toward durable, tissue-level molecular changes that outlast the glycemic exposure that initiated them.

Despite considerable advances in glucose-lowering pharmacotherapy over the past two decades, the burden of diabetic complications remains disproportionately high relative to improvements in glycemic control alone, suggesting that hyperglycemia exerts its damage through mechanisms only partially addressed by glucose reduction itself. Oxidative stress and chronic low-grade inflammation have emerged as central, mechanistically interconnected pathways linking hyperglycemia to both insulin resistance and end-organ injury. This review examines the molecular mechanisms by which sustained hyperglycemia drives oxidative stress and inflammatory signaling, and how these interlinked pathways underlie the pathogenesis and progression of T2DM, with the aim of consolidating a fragmented mechanistic literature into a single, clinically oriented narrative framework.

2. CELLULAR AND MOLECULAR MECHANISMS OF INSULIN RESISTANCE IN TYPE 2 DIABETES

Insulin Synthesis and Secretion:

Insulin is a 51-residue anabolic peptide hormone synthesized as preproinsulin and processed through sequential proteolytic cleavage into its mature disulfide-linked A- and B-chain conformation within the secretory granules of pancreatic β-cells residing in the Islets of Langerhans. Nutrient-stimulated insulin release is not a unitary event but a biphasic process, comprising an early, readily releasable pool of pre-docked granules followed by a sustained second phase dependent on granule mobilization and biosynthesis; this secretory dynamic is substantially potentiated by incretin hormones, principally glucagon-like peptide-1 (GLP-1) and gastric inhibitory polypeptide (GIP), which amplify glucose-stimulated insulin secretion through cAMP/PKA-dependent potentiation of β-cell exocytotic machinery.[10]

Insulin Receptor Structure and Downstream Signaling Pathways:

Insulin exerts its pleiotropic metabolic effects through the insulin receptor (IR), a disulfide-linked heterotetrameric ($\alpha_2\beta_2$) member of the receptor tyrosine kinase superfamily, orchestrating glucose disposal predominantly in skeletal muscle and adipose tissue via GLUT4 transporter translocation, while concomitantly exerting suppressive control over hepatic gluconeogenic flux (Figure 1). Ligand engagement induces conformational activation and trans-autophosphorylation of the receptor's intracellular tyrosine kinase domains, generating phosphotyrosine docking motifs that recruit and phosphorylate insulin receptor substrate proteins, principally IRS-1 and IRS-2; alongside Shc adaptor proteins, thereby nucleating multiprotein signalling complexes.

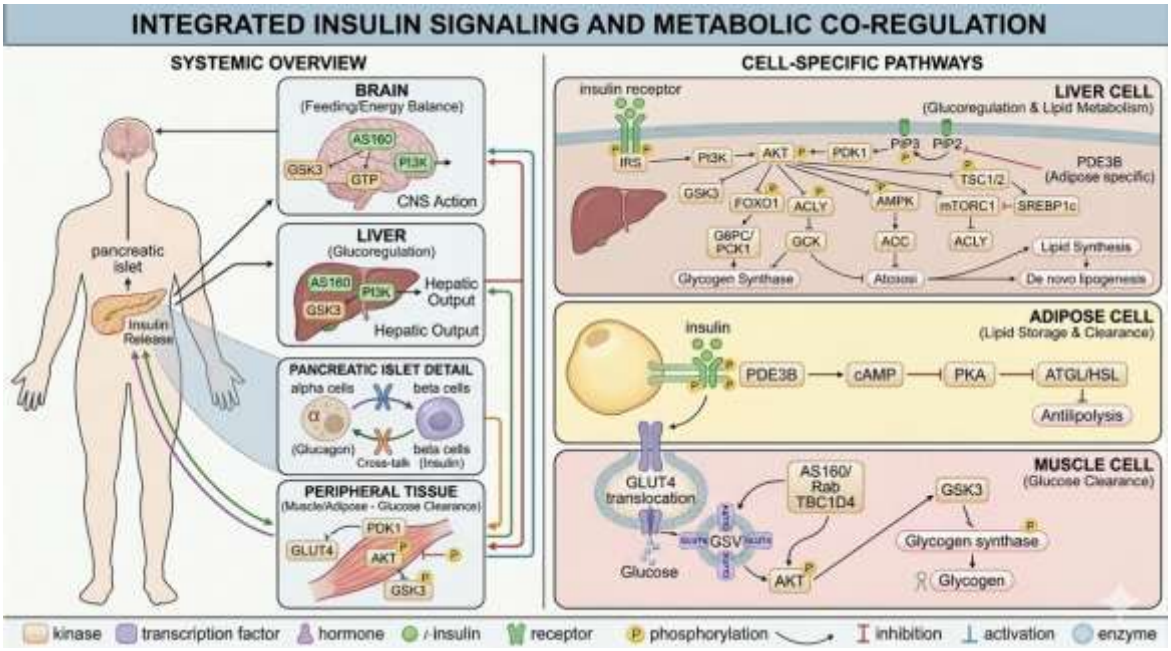


Figure 1. Integrated insulin signalling and metabolic regulation.

Downstream signal propagation bifurcates into two functionally distinct cascades: the phosphoinositide 3-kinase (PI3K)/Akt axis (Figure 2), which subserves the metabolic and anabolic actions of insulin, and the Raf/Ras/MEK/mitogen-activated protein kinase (MAPK) pathway (Figure 3), which governs mitogenic, proliferative, and growth-regulatory programmes.[11]

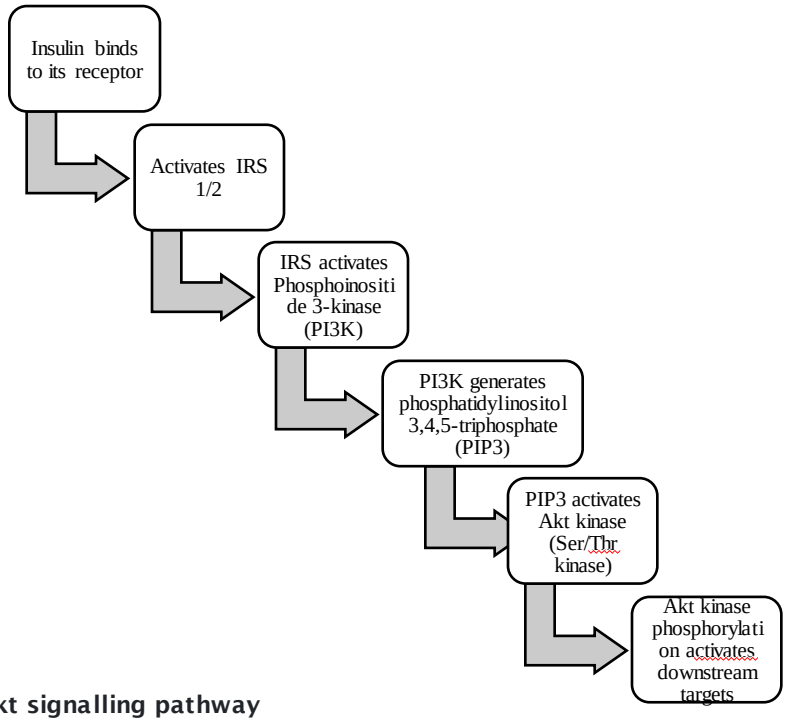


Fig. 2: PI3K/Akt signalling pathway

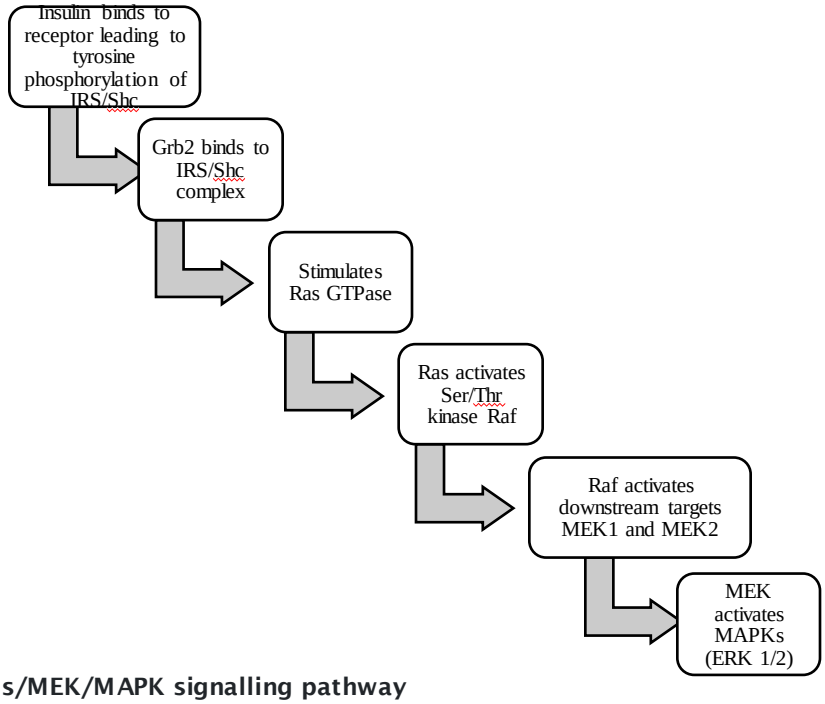


Fig. 3: Raf/Ras/MEK/MAPK signalling pathway

In T2DM, insulin-target tissues exhibit attenuated responsiveness to physiological hormone concentrations. This, a pathophysiological state designatesd insulin resistance., Itswhose molecular substrate is now understood to involves extensive lipotoxic and cytokine-mediated interference with proximal insulin signalling. Elevated circulating free fatty acids (FFAs), intracellular diacylglycerols (DAGs), and pro-inflammatory cytokines converge to disrupt canonical signal transduction at multiple nodes.

Tumor necrosis factor-alpha (TNF-α) drives this disruption by activatinges stress-responsive serine kinases, c-Jun N-terminal kinase (JNK) and IκB kinase-β (IKKβ), which catalyze aberrant inhibitory serine/threonine phosphorylation of IRS-1. This modification, sterically impairsing the tyrosine-phosphorylation-dependent coupling of IRS-1 to the activated insulin receptor,its physiological tyrosine-phosphorylation-dependent coupling to the activated IRwhich subsequently blocks and abrogating Akt-mediated GLUT4 vesicle translocation.[12] Concurrently, the lipid phosphatase PTEN dephosphorylates the phosphoinositide second messenger PIP_3, truncating the phosphoinositide gradient required for Akt membrane recruitment and activation. Meanwhile, , while adipocyte-derived interleukin-6 (IL-6) engages JAK-STAT signalling to induce suppressor of cytokine signalling (SOCS) proteins. These SOCS proteins, which target IRS-1/2 for ubiquitin-mediated proteasomal degradation.

Together, these distinct mechanismshese mechanistically distinct yet convergent insults, serine/threonine hyperphosphorylation, phosphoinositide depletion, and substrate degradation, collectively attenuate flux through the PI3K/Akt axis at multiple hierarchical levels, establishing a durable, self-reinforcing state of cellular insulin resistance that constitutes the molecular substrate of T2DM.[13] (Figure 4)

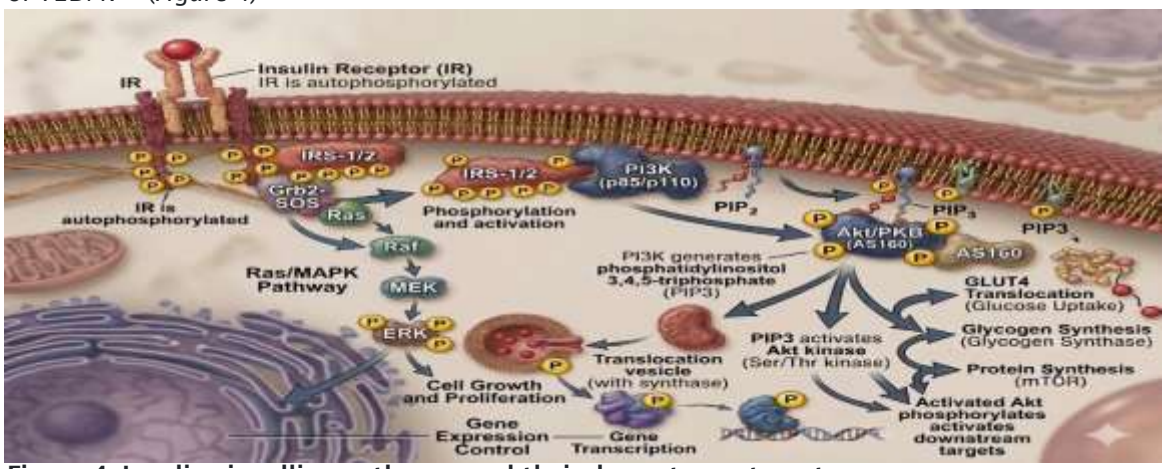


Figure 4. Insulin signalling pathways and their downstream targets.

3. ETIOPATHOGENESIS OF HYPERGLYCEMIA IN TYPE 2 DIABETES

When peripheral tissues develop insulin resistance, glucose disposal via GLUT4-mediated uptake becomes progressively impaired, shifting the burden of glycemic regulation onto hepatic glucose handling. Concurrent hepatic insulin resistance permits unrestrained transcriptional derepression of gluconeogenic enzymes, notably glucose-6-phosphatase and phosphoenolpyruvate carboxykinase (PEPCK), via impaired FoxO1 inhibition, thereby amplifying endogenous glucose output and establishing a self-perpetuating cycle of systemic hyperglycemia.[14] Pancreatic β-cells initially mount a compensatory response through hyperplastic and hypertrophic expansion of functional β-cell mass, sustaining compensatory hyperinsulinemia sufficient to offset peripheral resistance. With prolonged exposure to chronic hyperglycemia, however, β-cells undergo progressive desensitization to glucose, a maladaptive state termed glucotoxicity, characterized by transcriptional downregulation of the glycemic sensor glucokinase and consequent attenuation of glucose-stimulated insulin secretion (GSIS). Sustained hyperglycemia additionally suppresses mitochondrial fatty acid β-oxidation through malonyl-CoA-mediated allosteric inhibition of carnitine palmitoyltransferase-1 (CPT-1), redirecting excess lipid substrate into non-oxidative esterification pathways and promoting intracellular diacylglycerol (DAG) accumulation, a lipotoxic intermediate implicated in further signalling dysfunction.

The resultant glucolipotoxic microenvironment precipitates endoplasmic reticulum (ER) stress and activation of the unfolded protein response, culminating in transcriptional downregulation of the master insulin gene regulators pancreatic duodenal homeobox-1 (PDX-1) and V-maf musculoaponeurotic fibrosarcoma oncogene homolog A (MAFA), both indispensable for maintaining β-cell identity and insulin biosynthetic capacity. Compounded by locally elevated pro-inflammatory cytokines, tumor necrosis factor-alpha (TNF-α) and interleukin-1β (IL-1β), arising from islet-resident macrophage activation, these convergent glucolipotoxic and inflammatory insults drive progressive, mechanistically interdependent β-cell dedifferentiation and apoptotic attrition. This cascade culminates in the decompensated phase of T2DM, marked by an irreversible decline in functional β-cell mass and secretory reserve, wherein compensatory hyperinsulinemia can no longer be sustained and overt, clinically manifest hyperglycemia ensues.[15]

4. HYPERGLYCEMIA-INDUCED OXIDATIVE STRESS AND METABOLIC DYSFUNCTION

Oxidative stress is classically conceptualized as a pathological imbalance between the generation of reactive oxidant species and the buffering capacity of endogenous antioxidant defences, culminating in disrupted redox signalling and cumulative macromolecular injury.[16] Under physiological conditions, glucose undergoes catabolism via the Embden-Meyerhof-Parnas glycolytic pathway, generating the reducing equivalents NADH and $FADH_2$, which donate electrons to complexes I and II of the mitochondrial electron transport chain to drive chemiosmotic ATP synthesis through oxidative phosphorylation.[17] During sustained hyperglycemia, however, excess substrate flux into the electron transport chain elevates the mitochondrial proton gradient beyond a critical threshold, inducing electron leakage at complex III and consequent overproduction of reactive oxygen species (ROS), including the hydroxyl radical ($OH\cdot$), superoxide anion ($O_2^{-}\cdot$), hydrogen peroxide (H_2O_2), and peroxynitrite ($ONOO^-$), the latter arising from the diffusion-limited reaction between superoxide and nitric oxide. Although enzymatic (superoxide dismutase, glutathione peroxidase, catalase) and non-enzymatic (vitamins A, C, and E, reduced glutathione) antioxidant systems ordinarily neutralize physiological ROS flux, the supraphysiological oxidant burden characteristic of T2DM exceeds this buffering capacity, precipitating a sustained state of oxidative stress.[16]

This unchecked ROS accumulation inflicts direct macromolecular injury, peroxidation of membrane lipids, oxidative carbonylation of structural and enzymatic proteins, and formation of mutagenic DNA lesions such as 8-hydroxy-2′-deoxyguanosine, while simultaneously functioning as a proximal trigger for four interlinked, mechanistically distinct pro-oxidative pathways that amplify and perpetuate cellular injury: the polyol pathway, advanced glycation end-product formation and receptor engagement, protein kinase C isoform activation, and hexosamine biosynthetic pathway flux. Rather than operating in isolation, these pathways converge on shared downstream mediators, most notably further ROS generation and redox-sensitive transcriptional activation, establishing oxidative stress as both a consequence and a self-amplifying driver of hyperglycemia-induced tissue injury in T2DM.[18]

4.1 The Polyol (Sorbitol) Pathway

The polyol pathway constitutes an accessory, NADPH-dependent route of glucose catabolism operative chiefly in tissues exhibiting insulin-independent glucose uptake, the lens, retina, peripheral nerves, kidney, and seminal vesicles, rendering these sites selectively vulnerable to hyperglycemic substrate flooding independent of insulin-mediated glucose transport regulation. The rate-limiting enzyme aldose reductase, a member of the NADPH-dependent aldo-keto reductase superfamily,

reduces glucose to sorbitol, which is subsequently oxidized to fructose by sorbitol dehydrogenase in an NAD^+-dependent reaction.[17] Under euglycemic conditions, aldose reductase exhibits low affinity for glucose relative to its physiological substrates and thus contributes negligibly to overall glucose disposal; however, during sustained hyperglycemia, saturation of the high-capacity glycolytic and hexokinase-mediated pathways diverts substantial glucose flux into this otherwise quiescent route. This shunting imposes a critical metabolic cost: aldose reductase-mediated glucose reduction consumes NADPH stoichiometrically, thereby depleting the cofactor pool required for glutathione reductase-mediated regeneration of reduced glutathione, the principal intracellular thiol antioxidant, and compounding the prevailing oxidative burden. Because sorbitol is a polar, poorly membrane-permeant polyol and is further metabolized inefficiently in tissues with limited sorbitol dehydrogenase expression, its intracellular accumulation generates a hypertonic gradient that drives osmotic water influx, cellular swelling, and structural injury. This osmotic-oxidative dual insult underlies several hallmark microvascular complications of diabetes, manifesting clinically as diabetic cataract formation, macular edema, retinopathy, peripheral neuropathy, and nephropathy, and positions the polyol pathway as a mechanistic nexus linking hyperglycemia, redox imbalance, and tissue-specific microvascular injury.[18]

4.2 Advanced Glycation End-Products (AGEs) and Receptor Activation (RAGE)

Advanced glycation end-products (AGEs) arise via the Maillard reaction, an irreversible, non-enzymatic cascade of cross-linking condensation reactions between reducing sugars and the nucleophilic amine groups of proteins, lipids, or nucleic acids, proceeding through unstable Schiff base and Amadori intermediates toward stable, heterogeneous AGE adducts, a process that occurs at a low, physiologically tolerable basal rate under euglycemic conditions.[17] Sustained hyperglycemia substantially accelerates the kinetics of AGE formation beyond the capacity of receptor-mediated and proteolytic clearance mechanisms, resulting in progressive tissue accumulation within the vasculature, renal parenchyma, peripheral nerves, ocular structures, and long-lived collagen matrices, the latter rendering AGE burden particularly cumulative given collagen's slow turnover. AGEs exert their pathogenic effects principally through engagement of RAGE (receptor for advanced glycation end-products), a multiligand pattern-recognition receptor of the immunoglobulin superfamily broadly expressed across cardiac, pulmonary, skeletal muscle, and vascular tissue, as well as neuronal, glial, endothelial, and innate immune cell populations. AGE-RAGE ligation triggers receptor dimerization and downstream activation of redox-sensitive transcription factors, including nuclear factor kappa B (NF-κB), activator protein-1 (AP-1), and forkhead box protein O4 (FoxO4), thereby propagating a self-sustaining signalling loop of inflammatory gene transcription, vascular endothelial injury, cellular **dysfunction**, and amplified ROS generation. Cross-linking of AGEs within structural vascular proteins, notably collagen and elastin, imparts pathological arterial stiffening and impaired vasoreactivity, promoting atherosclerotic plaque development, coronary artery disease, and cerebrovascular events, while tissue-resident AGE accumulation independently and synergistically contributes to the microvascular pathology underlying diabetic retinopathy, nephropathy, and peripheral neuropathy.[19]

4.3 Activation of Protein Kinase C (PKC) Isoforms

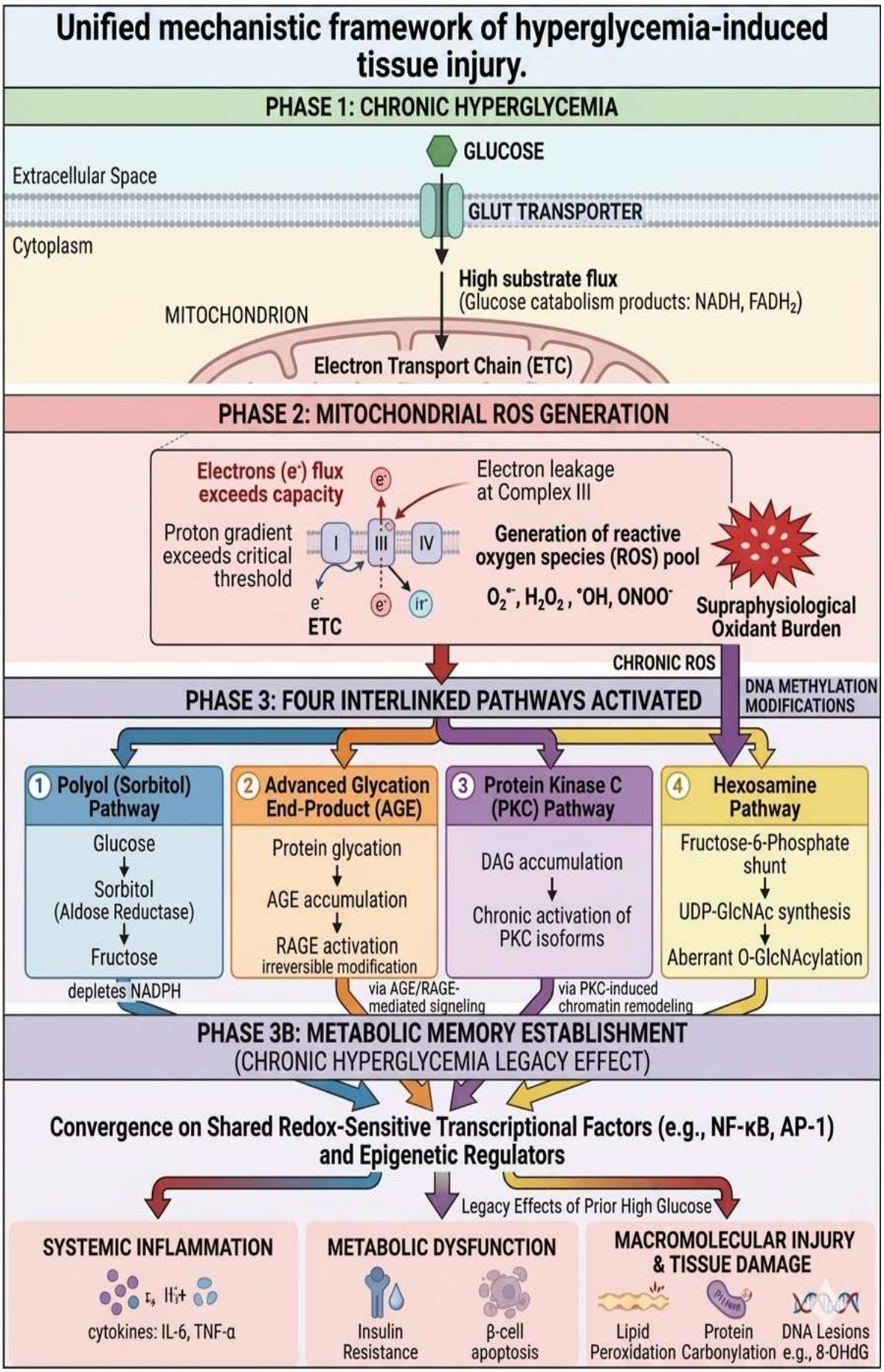
Protein kinase C (PKC) constitutes a structurally diverse family of serine/threonine kinases, comprising conventional (calcium- and DAG-dependent), novel (calcium-independent, DAG-dependent), and atypical isoforms, each regulating distinct downstream substrate networks through phosphorylation-dependent conformational activation. Under physiological glycolytic flux, glyceraldehyde-3-phosphate, a triose phosphate intermediate generated by aldolase-mediated cleavage of fructose-1,6-bisphosphate — exists in reversible enzymatic equilibrium with its structural isomer dihydroxyacetone phosphate via triose phosphate isomerase, the latter serving as the obligate precursor for glycerol-3-phosphate synthesis and, by extension, the glycerol backbone of triglycerides and membrane phospholipids. During sustained hyperglycemia, however, glycolytic substrate loading shifts this equilibrium toward dihydroxyacetone phosphate accumulation, driving its enzymatic reduction to glycerol-3-phosphate and subsequent de novo synthesis of diacylglycerol (DAG), a lipid second messenger and the principal endogenous allosteric activator of conventional and novel PKC isoforms. Hyperglycemia-induced DAG accumulation thus produces sustained, pathological PKC activation, in contrast to the transient, tightly regulated activation characteristic of physiological signal transduction. Once activated, PKC isoforms, particularly PKC-β and PKC-δ, phosphorylate a broad array of downstream effectors implicated in vascular pathology, including NADPH oxidase subunits, endothelial nitric oxide synthase, and components of the mitochondrial electron transport chain, thereby further augmenting ROS generation. This establishes a self-propagating feed-forward loop in which hyperglycemia-driven DAG-PKC signalling both originates from and perpetuates oxidative injury, contributing mechanistically to the vascular permeability defects, basement membrane thickening, and hemodynamic abnormalities characteristic of diabetic microvascular complications.[20]

4.4 Hexosamine Pathway Flux

The hexosamine biosynthetic pathway (HBP) constitutes a nutrient-sensing metabolic offshoot that diverts a minor fraction of glycolytic flux away from glycolysis proper, supporting the biosynthesis of uridine diphosphate N-acetylglucosamine (UDP-GlcNAc), the obligate substrate for N-linked and O-linked (O-GlcNAcylation) glycosylation reactions that dynamically regulate protein stability, subcellular localization, transcriptional activity, and intracellular signal transduction. Under physiological conditions, the rate-limiting enzyme glutamine:fructose-6-phosphate amidotransferase (GFAT) catalyzes the committed step of the pathway, converting fructose-6-phosphate and glutamine to glucosamine-6-phosphate, which is subsequently processed through a series of acetylation, isomerization, and uridylation reactions to yield UDP-GlcNAc, thereby coupling cellular nutrient status to protein post-translational modification. During sustained hyperglycemia, however, glycolytic substrate excess drives transcriptional and enzymatic upregulation of GFAT, disproportionately elevating flux through the HBP and generating supraphysiological UDP-GlcNAc pools. This excess substrate availability promotes aberrant O-GlcNAcylation of key transcriptional regulators, including Sp1, resulting in increased expression of transforming growth factor-α and -β (TGF-α, TGF-β) and plasminogen activator inhibitor-1 (PAI-1). Upregulated TGF-β signalling suppresses mesangial cell mitogenesis while concurrently promoting extracellular matrix accumulation, mesangial expansion, and glomerular basement membrane thickening, structural alterations that are pathological hallmarks of early diabetic nephropathy. More broadly, hexosamine pathway-driven O-GlcNAcylation interferes with insulin signalling by competitively modifying serine/threonine residues otherwise targeted for phosphorylation, thereby establishing a further mechanistic link between glucose-flux-dependent post-translational modification, extracellular matrix dysregulation, and the vascular, renal, and neural injury characteristic of chronic hyperglycemic exposure.[20]

4.5 Metabolic Memory: Persistent Injury Beyond Glycemic Correction

Beyond these four canonical pathways lies the phenomenon of "metabolic memory," a paradigm-shifting concept establishing that a preceding period of chronic hyperglycemic exposure confers durable, self-sustaining tissue injury that continues to drive microvascular and macrovascular complication progression despite subsequent attainment of near-normoglycemic control, a finding first substantiated by extended post-trial follow-up of intensively versus conventionally treated cohorts, wherein early glycemic divergence produced complication risk trajectories that persisted for years after glycemic parity was achieved between groups. Mechanistically, this persistence is attributed to the convergence of several self-perpetuating processes: sustained mitochondrial ROS overproduction that outlasts the initiating hyperglycemic stimulus, ongoing accumulation of irreversibly cross-linked, slowly-turned-over AGEs within long-lived structural proteins, and, most notably, epigenetic reprogramming of the cellular transcriptional landscape. This epigenetic dimension encompasses aberrant DNA methylation at promoter regions of key metabolic and inflammatory genes, altered histone methylation marks (notably H3K4 and H3K9 methylation at the NF-κB p65 promoter), and dysregulated histone acetylation, collectively producing a chromatin configuration that "locks" pro-inflammatory and pro-oxidative gene expression programmes, including NF-κB-responsive genes, in a constitutively activated, transcriptionally permissive state that is resistant to subsequent normalization of glycemia. Because these epigenetic marks are heritable across cell divisions and only slowly reversible, metabolic memory effectively converts a transient physiological exposure into a durable pathological trait embedded within the cellular transcriptional apparatus. This mechanistic understanding constitutes compelling biological rationale for early, intensive glycemic intervention at the point of diagnosis, rather than delayed, stepwise, or incremental treatment escalation, positioning the earliest phase of disease management as a critical, time-limited therapeutic window.[21].


Unified mechanistic framework of hyperglycemia-induced tissue injury.
PHASE 1: CHRONIC HYPERGLYCEMIA
GLUCOSE
Extracellular Space
GLUT TRANSPORTER
Cytoplasm
High substrate flux
(Glucose catabolism products: NADH, FADH2)
MITOCHONDRION
Electron Transport Chain (ETC)
PHASE 2: MITOCHONDRIAL ROS GENERATION
Electrons (e-) flux exceeds capacity
Electron leakage at Complex III
Proton gradient exceeds critical threshold
I
III
IV
ETC
Generation of reactive oxygen species (ROS) pool
O2•-, H2O2, •OH, ONOO-
Supraphysiological Oxidant Burden
CHRONIC ROS
DNA METHYLATION MODIFICATIONS
PHASE 3: FOUR INTERLINKED PATHWAYS ACTIVATED
1 Polyol (Sorbitol) Pathway
Glucose
Sorbitol (Aldose Reductase)
Fructose
depletes NADPH
2 Advanced Glycation End-Product (AGE)
Protein glycation
AGE accumulation
RAGE activation
irreversible modification
via AGE/RAGE-mediated signeling
3 Protein Kinase C (PKC) Pathway
DAG accumulation
Chronic activation of PKC isoforms
via PKC-induced chromatin remodeling
4 Hexosamine Pathway
Fructose-6-Phosphate shunt
UDP-GlcNAc synthesis
Aberrant O-GlcNAcylation
PHASE 3B: METABOLIC MEMORY ESTABLISHMENT
(CHRONIC HYPERGLYCEMIA LEGACY EFFECT)
Convergence on Shared Redox-Sensitive Transcriptional Factors (e.g., NF-κB, AP-1) and Epigenetic Regulators
Legacy Effects of Prior High Glucose
SYSTEMIC INFLAMMATION
cytokines: IL-6, TNF-α
METABOLIC DYSFUNCTION
Insulin Resistance
β-cell apoptosis
MACROMOLECULAR INJURY & TISSUE DAMAGE
Lipid Peroxidation
Protein Carbonylation
DNA Lesions e.g., 8-OHdG

5. MOLECULAR CROSSTALK: FROM OXIDATIVE STRESS TO CHRONIC INFLAMMATION

Oxidative stress and inflammation are increasingly recognized as mechanistically interdependent, bidirectionally coupled processes rather than discrete, sequentially ordered pathological events, reflecting a shared evolutionary origin in innate cellular stress-response signalling. Reactive oxygen species promote inflammatory activation through both direct and indirect mechanisms: directly, via oxidative modification of membrane phospholipids and release of lipid-derived inflammatory mediators such as oxidized low-density lipoprotein and eicosanoids; and indirectly, through redox-sensitive activation of a broad transcriptional network encompassing peroxisome proliferator-activated receptor-gamma (PPAR-γ), nuclear factor kappa B (NF-κB), activator protein-1, p53, nuclear factor erythroid 2-related factor 2 (Nrf2), and hypoxia-inducible factor-1α (HIF-1α), several of which exhibit reciprocal cross-regulation that further amplifies the inflammatory transcriptional output. Among these, NF-κB occupies a position of particular mechanistic centrality, constituting a family of structurally related, inducible transcription factors, including the canonical p65/p50 heterodimer, that govern innate and adaptive immunity, inflammatory gene expression, cell survival, and proliferative signalling. Under quiescent basal conditions, NF-κB dimers are held in transcriptionally inert cytoplasmic sequestration through stoichiometric association with their inhibitory protein, IκB, which masks the nuclear localization sequence and thereby prevents nuclear entry. ROS-mediated activation of the IκB kinase (IKK) complex catalyzes phosphorylation-dependent ubiquitination and proteasome degradation of IκB, liberating NF-κB for nuclear translocation and subsequent transactivation of a broad inflammatory gene programme encoding interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α). The resulting cytokine milieu drives endothelial dysfunction through impaired nitric oxide bioavailability, promotes vascular smooth muscle cell proliferation and migration, and accelerates atherogenic plaque formation, thereby mechanistically linking redox dysregulation to the macro vascular complications of chronic hyperglycemia.

Critically, this inflammatory activation does not remain confined to vascular tissue but directly reinforces the insulin-resistant phenotype at the level of proximal insulin signalling, establishing a pathogenic convergence between the inflammatory and metabolic disease axes. Activated IKK-β, in addition to its canonical role in NF-κB liberation, exerts a moonlighting kinase function by directly phosphorylating insulin receptor substrate-1 and -2 (IRS-1/2) on inhibitory serine residues, a modification that stands in direct mechanistic opposition to the physiological tyrosine phosphorylation induced by ligand-activated insulin receptor auto phosphorylation. Because serine-phosphorylated IRS-1/2 exhibits diminished capacity to couple productively with the activated insulin receptor and to nucleate downstream phosphoinositide 3-kinase (PI3K)/Akt signalling complexes, this post-translational modification functions as a molecular switch that actively uncouples insulin receptor activation from its physiological metabolic output. Consequently, this reciprocal cross-talk establishes a self-amplifying, feed-forward pathological cycle in which oxidative stress drives NF-κB/IKK-β-dependent inflammatory activation, inflammatory signalling in turn deepens insulin resistance through serine-phosphorylation-mediated IRS-1/2 inactivation, and the resulting metabolic dysregulation generates further substrate-driven ROS overproduction — collectively constituting a mechanistically closed, self-perpetuating circuit that sustains and progressively intensifies the pathophysiological trajectory of type 2 diabetes mellitus.[22]

6. CONCLUSION AND FUTURE PERSPECTIVES

The convergence of insulin signalling defects, hyperglycemia-driven oxidative stress, and NF-κB-mediated inflammatory activation forms a self-reinforcing molecular circuit that underlies both the initiation and progression of T2DM and its vascular complications. The phenomenon of metabolic memory reinforces the clinical principle that early, intensive glycemic control is essential to limit the durable, epigenetically encoded tissue injury that persists even after glycemic targets are subsequently achieved.

Translating this mechanistic understanding into clinical benefit will require several parallel advances: the development of accessible, non-invasive biomarkers (e.g. urinary 8-OHdG and MDA; salivary AGEs, CRP, and IL-6; urinary or salivary exosomal miRNAs) that more accurately reflect real-time insulin sensitivity, β-cell function, and oxidative burden; targeted screening strategies for earlier identification of at-risk individuals; and public health interventions promoting dietary modification and regular aerobic activity as first-line, modifiable interventions. Furthermore, since oxidative injury begins early on, future research must prioritise targeted screening as well as precision medicine framework approaches (individualised therapies, molecular phenotyping) integrated with machine learning algorithms, to intercept well before the occurrence of irreversible tissue damage. Emerging antioxidant- and anti-inflammatory-targeted therapeutics, alongside conventional glucose-lowering agents – most notably GLP-1 receptor agonists and SGLT2 inhibitors -, warrant continued investigation as adjuncts capable of interrupting the oxidative-inflammatory cycle described in this

review. Apart from glycemic control, their well-established cardio-protective and reno-protective effects strongly support their ability to directly mitigate mitochondrial injury, oxidative stress, chronic inflammation and endothelial dysfunction in T2DM. A deeper understanding of the interplay between insulin resistance, insulin secretory capacity, and redox and inflammatory signalling remains central to the development of more effective, mechanistically informed therapeutic strategies for T2DM.

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IFCC WorldLab New Delhi 2026:

The Global Conversation Shaping the Future of Laboratory Medicine and Healthcare

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The 27th International Congress of Clinical Chemistry and Laboratory Medicine (IFCC WorldLab New Delhi 2026) organized by the IFCC, the world's most influential global congress in laboratory medicine will be hosted by the Association of Clinical Biochemists of India (ACBI) in the vibrant city of New Delhi, India. The Congress will be held in the India's largest International Convention and Exhibition Center (IICC), located in Dwarka, New Delhi, 10 km from Indira Gandhi International airport and Aerocity. Metro station is located inside the exhibition complex connecting IICC to the Airport, Aerocity hotels and central New Delhi. 3500 hotel rooms are available within the IICC complex and 3600 rooms in the adjacent Aerocity. We look forward to welcoming you to this distinguished gathering of experts, fostering scientific exchange, innovation, and collaboration in laboratory medicine.

As a global federation, IFCC plays a central role in fostering collaboration across regions, disciplines, and professional communities to support high-quality laboratory services worldwide. International cooperation and the sharing of best practices are essential drivers of quality, harmonization, and innovation in laboratory medicine. Through its divisions, task forces, committees and working groups, IFCC promotes coordinated scientific activities, knowledge exchange, and strategic initiatives aimed at strengthening laboratory medicine worldwide. These collective efforts support scientific advancement, enhance education and training, and contribute to building a strong global professional network.

The decision to choose IFCC WorldLab 2026 (25-29. October 2026) in New Delhi reflects a strategic vision at a time when healthcare is being transformed by digital technologies, artificial intelligence, precision medicine and new models of care delivery. New Delhi offers a uniquely relevant environment in which to explore these developments. As one of the world's most dynamic centers for innovation, biomedical research, digital health and healthcare entrepreneurship, the city provides an ideal setting for a congress dedicated to the future of laboratory medicine.

Building upon decades of successful annual congresses organized by the Association of Clinical Biochemists of India (ACBI) (see appendix Table), which have fostered scientific exchange and professional development across the Indian subcontinent, while strengthening collaborations with IFCC, APFCB and WASPaLM, WorldLab Delhi 2026 represents a natural continuation of a long-standing commitment to scientific excellence and international cooperation.

A distinctive feature of WorldLab 2026 is the active contribution of every IFCC Regional Federation. Rather than presenting isolated regional perspectives, the programme creates a global dialogue where experiences from Africa, Asia-Pacific region, Europe, Latin America, North America and Arab Federation converge around common objectives: improving patient care, strengthening public health and accelerating innovation. Few scientific organizations can bring together such a diversity of expertise within a single scientific programme. This international engagement is reflected in the remarkable scientific response already received. Many abstracts have been submitted from 77 countries (more than 1300) and many more are expected till the deadline of June 20, 2026. Particularly encouraging is the strong participation from Africa, Europe, Middle East, Latin America and Asia, highlighting the growing role of laboratory medicine in supporting healthcare development, public health strategies and scientific capacity building across rapidly evolving healthcare systems.

Beyond the numbers, however, the true strength of WorldLab 2026 lies in the story told by its scientific programme. A common thread runs throughout the congress: the transition from data generation to clinical intelligence. Whether discussing artificial intelligence, advanced biomarkers, liquid biopsy, mass spectrometry, cybersecurity, newborn screening, antimicrobial resistance, integrative diagnostics or digital health ecosystems, the same question repeatedly emerges: how can laboratory medicine transform increasingly complex information into better decisions for patients, clinicians and healthcare systems? The programme illustrates how laboratory medicine is evolving into a central component of future healthcare. Advances in liquid biopsy, cell-free DNA technologies, multi-omics, neurodegenerative biomarkers, reproductive medicine and precision oncology are opening new perspectives for earlier diagnosis, individualized treatment and improved patient outcomes. At the same time, innovations in automation, digital connectivity and data science are redefining how laboratories interact with clinicians, healthcare institutions and public health authorities.

Another powerful message emerging from the programme is the convergence between precision medicine and population health. Technologies capable of characterizing disease at the molecular level now coexist with global initiatives addressing tuberculosis, antimicrobial resistance, diabetes, cardiovascular disease, newborn screening and One Health approaches. Together, these themes demonstrate that the future of healthcare will increasingly rely on the ability to integrate personalized medicine with public health strategies capable of benefiting entire populations. Importantly, technological innovation is consistently balanced by discussions on ethics, quality, metrological traceability, leadership, education and scientific integrity. The future laboratory will not be defined solely by technological performance but by its capacity to deliver trustworthy, clinically meaningful and actionable information.

The plenary lectures reinforce this vision. Topics ranging from tuberculosis diagnostics and cancer detection through cell-free DNA technologies to cardiovascular disease prevention, metrology in healthcare and the future impact of artificial intelligence and total laboratory automation highlight the expanding contribution of laboratory medicine to both clinical care and public health.

The **IVD sector is central to the Congress**, leading high-level educational workshops with eminent speakers and hosting a large-scale industrial exhibition. These activities provide a powerful platform to showcase innovations, launch new solutions, strengthen customer relationships, and gain insight into emerging clinical and market needs, particularly in fast-growing regions. The IFCC Executive Board recently approved additional benefits for IVD companies attending the WorldLab Delhi Congress. Details can be obtained from the Professional Congress Organizer (MZ Events).

Importantly, visa arrangements have been carefully planned and coordinated by MZ Events in close collaboration with local authorities, to ensure smooth participation for IVD companies, exhibitors, and all international participants. Approximately 2,000 delegates typically attend host society meetings, and attendance is expected to increase further with the involvement of three Indian IFCC-affiliated societies. Reduced registration fees have been introduced for participants from low- and lower-middle-income countries, including India, with the expectation of significantly increasing participation while maintaining financial balance.

Particularly noteworthy is the satellite meeting organized by the IFCC Committee-Point of Care Testing (C-POCT) dedicated to **"New Developments and Opportunities for Point-of-Care Testing with a Focus on Developing Countries."** As diagnostic technologies become increasingly portable, connected and accessible, point-of-care testing is emerging as one of the most powerful instruments for expanding access to quality healthcare. This satellite meeting perfectly reflects IFCC's commitment to ensuring that innovation contributes not only to scientific progress but also to greater equity in healthcare worldwide.

A pre-congress practical workshop on a very interesting hot topic entitled “Building your first AI Model: A Practical Session” will be organized on 25.10.2026, by GIPMER, ACBI and IFCC ETD.

IFCC is equally committed to supporting the next generation of laboratory professionals. As in previous editions, WorldLab 2026 will host the **IFCC Young Scientist FORUM**, with scholarships available to support early-career professionals. This initiative offers a unique opportunity for young scientists to engage with leading experts, exchange knowledge and expertise, and benefit from extensive networking within an international and multidisciplinary environment, including interactions with major industry representatives. Such events are invaluable opportunities to exchange ideas, foster collaboration, and continue advancing our discipline while expanding professional horizons. Travel grants, educational opportunities and dedicated activities are available to encourage the participation of young scientists and emerging leaders from all regions of the world. Their engagement is essential, as they will help define the future direction of our profession. Whether your interests lie in artificial intelligence, precision medicine, digital health, advanced diagnostics, public health, laboratory management, point-of-care testing or emerging technologies, WorldLab New Delhi 2026 offers a unique opportunity to learn, exchange ideas, establish new collaborations and contribute to the global conversation shaping tomorrow's healthcare. The future of laboratory medicine will not be written by a single institution, a single technology or a single country. It will be written by the scientists, clinicians, laboratory professionals, educators and innovators who choose to come together, share their expertise and build solutions for patients worldwide.

In addition, the Congress is being organized as a **green and sustainable event**, aligning innovation with environmental responsibility, an increasingly important value for global healthcare companies.

WorldLab New Delhi 2026 is more than a scientific congress. It is a unique opportunity to engage with the ideas, technologies and collaborations that will shape the next decade of healthcare. As the global organization representing laboratory medicine, IFCC continues to provide a unique platform where science, education, innovation, industry, public health institutions and healthcare leaders can come together to address challenges that transcend national borders. Through its worldwide network of Federations, Divisions, Committees, and Working Groups, IFCC remains the leading international voice for laboratory medicine, promoting excellence, harmonization, education and innovation for the benefit of patients everywhere.

New Delhi will not simply host the next WorldLab 2026. It will host a global conversation about the future of healthcare. We invite you to be part of that conversation: Discover what comes next, build partnership, and challenge conventional thinking. Contribute to the next chapter of laboratory medicine. As Mahatma Gandhi reminded us: **"The future depends on what we do today"** . This principle resonates strongly with the mission of IFCC and the spirit of WorldLab.

Join us at IFCC WorldLab New Delhi 2026. Be part of the conversation. Be part of the future, Help create it !

The **Mahatma Gandhi statue** seated in the courtyard of the Parliament of India in New Delhi is the most powerful public representation of this legendary leader, symbolizing love against violence, resistance against colonialism, and an eternal will born out of perceived weakness. (courtesy of **Bugra YURDAKUL**)

India Gate in Lutyen's Delhi was constructed in 1931, this iconic landmark is more than just a stunning feat of architecture. India Gate is counted among the largest war memorials in India

Appendix – ACBICON Congresses Attended or Documented by Bernard Gouget (2007–2025)

Year	ACBICON Venue
2007	New Delhi
2008	Kolkata
2009	Kochi
2010	Mumbai
2011	Gwalior
2012	Ranchi
2013	New Delhi
2014	Jodhpur*
2015	Chandigarh
2016	Mangalore
2017	Lucknow
2018	Panaji (Goa)
2019	Jaipur (ACBI- APFCB Congress)
2020	Kolkata
2021	Virtual Congress (organized from Kalyani/Kolkata)
2022	New Delhi
2023	Thiruvananthapuram
2024	Chandigarh (Golden Jubilee ACBICON)
2025	Pune (Joint ACBICON-WASPaLM
2026	New DEHLI

IFCC President's Commentary: Shaping the Future of Laboratory Medicine

Prof. Dr Tomris Ozben, EuSpLM, Ph.D., D.Sc., Specialist in Medical Biochemistry
IFCC, President
EFLM, Past-President
BCLF, Past President
Akdeniz University, Medical Faculty, Dept. of Medical Biochemistry, Antalya Turkiye
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As President of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC), I am honoured to reflect on the remarkable journey of our organization and to share our vision and mission for the future of laboratory medicine. For more than seven decades, IFCC has served as the leading global organization dedicated to advancing clinical chemistry and laboratory medicine, supporting healthcare professionals, promoting scientific excellence, and improving patient outcomes worldwide.

Today, laboratory medicine plays a central role in modern healthcare. It is widely recognized that more than 70% of medical diagnoses and clinical decisions rely on laboratory data. From disease prevention and early diagnosis to treatment monitoring and personalized medicine, laboratory professionals provide the critical information that guides patient care. As healthcare systems become increasingly data-driven and technologically advanced, the contribution of laboratory medicine continues to expand, creating new opportunities and responsibilities for our profession.

The mission of IFCC is clear: **to be the leading organization in the field of Clinical Chemistry and Laboratory Medicine worldwide.** Through leadership, innovation, education, and scientific excellence, we strive to improve the quality of diagnosis and therapy for patients across the globe

Reflecting the evolving role of laboratory medicine in healthcare, IFCC has adopted the following mission statement:

"Advancing excellence in laboratory medicine for better healthcare worldwide."

This mission is more than a statement; it is a commitment to patients, healthcare professionals, and society. It reflects IFCC's determination to ensure that laboratory medicine remains at the forefront of scientific discovery, clinical innovation, education and healthcare transformation.

To support, enhance and achieve this mission, IFCC provides continuous scientific and education opportunities for its members and develops programs that directly impact patient healthcare through improvements in laboratory medicine services. IFCC serves as the unifying organization for laboratory professionals worldwide, offering education, scientific resources, and research initiatives. We work closely with national societies, regional federations, academic institutions, healthcare organizations, and industry partners to promote harmonization, standardization, education, research, and quality improvement across all regions of the world. We believe that excellence in laboratory medicine should be accessible to every patient, regardless of geographic location or economic circumstances.

IFCC is committed to supporting global cooperation in key areas such as knowledge exchange, standardization, education, and capacity building. By sharing expertise and best practices, we aim to enhance patient care, support professional development, and reduce variability in laboratory medicine across different healthcare settings.

Particular emphasize is placed on collaborative efforts to develop clinical guidelines, consensus documents, and recommendations that support harmonized laboratory practices and evidence-based decision-making. IFCC also recognizes the growing importance of digital education through e-learning platforms, webinars, and online resources, which are essential for expanding access to knowledge and supporting continuous professional development worldwide, particularly in resource-limited settings.

As a global federation, IFCC plays a central role in fostering collaboration across regions, disciplines, and professional communities to support high-quality laboratory services worldwide. International cooperation and the sharing of best practices are essential drivers of quality, harmonization, and innovation in laboratory medicine. Through its divisions, task forces, committees and working groups, IFCC promotes coordinated scientific activities, knowledge exchange, and strategic initiatives aimed at strengthening laboratory medicine globally. These collective efforts support scientific advancement, enhance education and training, and contribute to building a strong global professional network.

The IFCC Strategic Action Plan 2024–2026 represents a major step toward realizing our long-term goals. Advancing healthcare through Laboratory Medicine relies on the active engagement and dedicated involvement of IFCC Member Societies, Corporate Members, and officers of IFCC Functional Units. Their collective efforts play a pivotal role in steering our profession toward the objectives outlined in the Strategic Action Plan.

The Strategic Action Plan was developed through extensive collaboration among the IFCC Executive Board, Functional Units, National Societies, and Corporate Members. Their valuable suggestions, ideas, and feedback helped shape the plan, ensuring that it reflects the diverse perspectives and expertise of our global community while focusing on areas where IFCC can make a direct and measurable impact on healthcare.

The Strategic Action Plan is organized around four key areas:

Area A: Supporting Membership
Area B: Broadening Horizons
Area C: Improving the Quality of Laboratory Medicine
Area D: Improving the Effectiveness of IFCC

The IFCC General Conference held on May 16,17, 2025, provided a pivotal gathering of the global IFCC community under the inspiring theme: ***"Connecting Science, Health, and Innovation: The Future Flows Like Water."*** This event served as an important platform for sharing progress, discussing ongoing initiatives, and shaping the future direction of Laboratory Medicine worldwide.

Global leaders in laboratory medicine, in vitro diagnostics, digital health, and medical technologies together with representatives from MedTech Europe, the World Health Organization (WHO), JCTLM, and the Global Diagnostics Alliance shared the latest innovations, partnership models, and strategies for integrating emerging technologies. The conference also explored critical challenges and future opportunities through interactive discussions and brainstorming sessions.

Our discussions focused on several strategic questions:

- What are the current challenges facing laboratory medicine?
- What future goals should we pursue?
- Where should we focus our efforts?
- How can we transform revolutionary ideas into practical action?
- How can collaboration among industry, academia, public institutions, and private organizations drive success in a rapidly evolving environment?

One of our highest priorities is improving healthcare outcomes globally. Through partnerships with organizations such as the World Health Organization and other international stakeholders, IFCC supports initiatives that strengthen laboratory services in developing countries. Programs such as newborn screening and laboratory capacity-building projects help ensure that high-quality diagnostic services reach populations that need them most.

Quality remains a cornerstone of our strategy. IFCC is committed to advancing laboratory quality worldwide through innovative external quality assessment programs, harmonized quality systems, and the promotion of total quality management. By supporting laboratories in achieving higher standards of performance, we contribute directly to safer and more effective patient care.

Another strategic objective is the development of a global consortium on reference intervals. Laboratory results can only be interpreted correctly when appropriate reference intervals are available. By collecting and integrating data from diverse populations worldwide, IFCC aims to create a global repository that supports harmonization and improves diagnostic accuracy across all age groups and healthcare settings.

Education continues to be one of our greatest strengths. Through our expanding eAcademy and distance-learning initiatives, IFCC is becoming the world's largest provider of free educational resources in laboratory medicine. Our goal is to support young scientists, trainees, educators, and healthcare professionals with high-quality learning opportunities regardless of where they live or work.

Equally important is our commitment to demonstrating and communicating the value of laboratory medicine. Evidence-based research consistently highlights the critical role that laboratory data plays in clinical decision-making and healthcare efficiency. IFCC actively supports studies and collaborative projects that generate robust evidence demonstrating how laboratory medicine improves patient outcomes, reduces healthcare costs, and enhances public health.

Innovation is another fundamental pillar of our strategy. The rapid emergence of artificial intelligence, machine learning, digital health, integrated diagnostics, laboratory automation, nanotechnology, microfluidics, molecular diagnostics, and multi-omics technologies is transforming healthcare at an unprecedented pace. IFCC is committed to ensuring that laboratory professionals play a leading role in shaping and implementing these advances.

As we look to the future, we see extraordinary opportunities for laboratory medicine. Advances in genomics, proteomics, metabolomics, artificial intelligence, and data analytics will continue to redefine how diseases are diagnosed, monitored, and prevented. Laboratory medicine will increasingly move beyond traditional testing to become a central component of predictive, preventive, personalized, and participatory healthcare.

Artificial intelligence, in particular, will have a profound impact on laboratory operations and clinical decision-making. From optimizing workflows and quality assurance processes to supporting result interpretation and clinical risk prediction, AI has the potential to improve efficiency, accuracy, and patient care. IFCC will continue to promote the responsible adoption of these technologies while ensuring transparency, ethical governance, and the preservation of professional expertise.

AI is revolutionizing laboratory medicine through faster and more accurate diagnostics, improved workflow efficiency, and enhanced decision support. However, its implementation must be guided by ethical principles and professional oversight. Human expertise remains indispensable; AI should support, not replace, clinical judgment. Continuous collaboration among clinicians, laboratory professionals, information technology experts, and researchers will be essential to fully realize the benefits of AI. Equally important is the education and training of future professionals to ensure they are prepared to work effectively in an increasingly digital healthcare environment.

We also anticipate greater integration between laboratory medicine and other healthcare disciplines. The future will require stronger collaboration among laboratory professionals, clinicians, researchers, informaticians, and policymakers. Through interdisciplinary partnerships, we can translate scientific discoveries into practical solutions that improve health outcomes for millions of people.

At the same time, global healthcare challenges, including aging populations, emerging diseases, health inequities, and resource limitations, will require innovative and sustainable solutions. IFCC is uniquely positioned to support the international laboratory community in addressing these challenges through education, standardization, advocacy, and scientific leadership.

The future of laboratory medicine has never been more exciting. Our profession stands at the intersection of science, technology, and patient care, with unprecedented opportunities to contribute to global health. IFCC will continue to lead this journey by fostering innovation, supporting education, promoting quality, and advocating for the essential role of laboratory medicine in healthcare systems worldwide.

Together with our members, partners, and volunteers, we will continue advancing excellence in laboratory medicine for better healthcare worldwide. By embracing innovation, strengthening global collaboration, and maintaining our unwavering commitment to patients, we can ensure that the next generation of laboratory medicine delivers even greater value to society than ever before.

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Case Report

Protein Electrophoresis Patterns in Orbital Apex Syndrome: A Case Series of Rare Diagnosis

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Abstract

Orbital Apex Syndrome (OAS) is a rare neuro-ophthalmic disorder characterized by multiple cranial nerve dysfunction, presenting with ophthalmoplegia, ptosis, proptosis, and sensory deficits. Its diverse neoplastic, inflammatory, infectious, traumatic, and vascular etiologies often delay diagnosis and increase the risk of irreversible visual loss. Although imaging localizes orbital lesions, it may not identify the underlying systemic etiology. Serum protein electrophoresis (SPE), detects occult systemic disorders, particularly plasma cell dyscrasias and inflammatory conditions associated with OAS. Early incorporation of SPE into the diagnostic workup may facilitate timely recognition of systemic diseases, with guided targeted investigations. Thereby improving clinical outcomes and preventing permanent neurological or visual sequelae enabling prompt initiation of appropriate therapy. Herein, we present a case series of three patients with OAS, highlighting the role of SPE in detecting underlying systemic disorders.

Keywords: Orbital Apex Syndrome, Serum protein electrophoresis, Laboratory medicine, Case series, Capillary electrophoresis

Introduction

Orbital Apex Syndrome (OAS) is a rare neuro-ophthalmic disorder caused by lesions involving the orbital apex, resulting in dysfunction of the optic nerve and cranial nerves III, IV, VI, and the ophthalmic division of the trigeminal nerve [1]. Clinical features include ophthalmoplegia, proptosis, ptosis, hypoesthesia of the forehead, and vision loss. OAS has a multifactorial etiology and may arise secondary to neoplastic, infectious, inflammatory, traumatic, or vascular disorders, including plasma cell dyscrasias, systemic lupus erythematosus, Tolosa–Hunt syndrome, bacterial or fungal sinusitis, herpes zoster, iatrogenic injury, craniomaxillofacial fractures, and cavernous sinus thrombosis [1,2].

Given the risk of irreversible visual loss, permanent cranial neuropathies, intracranial spread, and potentially life-threatening complications, OAS requires prompt diagnosis and treatment. However, its heterogeneous etiologies, nonspecific clinical manifestations, and overlap with other orbital and neuro-ophthalmic disorders often make early diagnosis challenging. Current evidence remains largely confined to isolated case reports and small case series, with limited data to inform standardized diagnostic strategies or the incorporation of adjunctive investigations, such as serum protein electrophoresis (SPE), into routine clinical practice [3-5]. While contrast-enhanced CT and MRI accurately localize orbital apex lesions and define their extent, they often do not establish the underlying systemic diagnosis, particularly in infiltrative or hematological disorders.Thus, Although imaging and histopathological examination remain the cornerstone of OAS diagnosis by localizing the orbital lesion, they often fail to identify the underlying systemic etiology [6]. In contrast, the diagnostic utility of laboratory investigations, particularly SPE, remains poorly characterized and is seldom discussed in the literature despite its potential to detect plasma cell dyscrasias and other systemic disorders that may underlie OAS. It is important because plasma cell dyscrasias and other monoclonal gammopathies may initially present with orbital involvement, inexpensive laboratory investigations such as SPE may provide an important diagnostic clue before systemic manifestations become clinically apparent [7]. We present a case series of three patients with OAS illustrating distinct underlying etiologies, highlighting the use of serum protein electrophoresis as an adjunctive investigation.

Case Reports

Case 1

A 45-year-old female patient presented with a 4-day history of right eye pain associated with blurred vision in both eyes. On examination, visual acuity was limited to finger counting at 1 m in both eyes. Extraocular movements were restricted in lateral and upward gaze in the right eye and in upward gaze in the left eye. Sensation was reduced in the left V1 distribution, while motor examination revealed no focal neurological deficits.

The laboratory, serological, and neuroimaging findings for all cases are detailed in Table 1. Complete blood count was within normal limits. Serum C-reactive protein (CRP), rheumatoid factor (RF), Hepatitis B surface antigen (HBsAg) and Hepatitis C antibodies (HCV) were negative. SPEP revealed polyclonal hypergammaglobulinemia (Figure 1B). Serum IgG4 was normal (0.94 g/L). Cerebrospinal fluid (CSF) analysis was unremarkable. Cartridge-Based Nucleic Acid Amplification Test (CB-NAAT) of the CSF was negative. Contrast-enhanced MRI of the orbits failed to demonstrate a localizing lesion. CECT brain and orbit revealed no significant abnormality. Ultrasonography (USG) of the whole abdomen and CECT of the chest and abdomen were unremarkable. Diagnosis of acute orbital apex syndrome was made clinically. The patient received intravenous immunoglobulin (IVIG), with subsequent clinical improvement.

Table 1: Laboratory, Serological, and Neuroimaging Findings of the Cases

Investigations	Case 1	Case 2	Case 3	Biological Reference Interval
AST	22	28	23	10-40 U/L
ALT	34	13	25	10-40 U/L
ALP	58	86	94	30-115 U/L
Total Protein	6.6	5.0	7.5	6-8 gm/dL
Albumin	4.1	2.1	4.3	3.5-5 gm/dL
Total Bilirubin	0.5	1.0	1.01	0.3-1.2 mg/dL
HbA1c	5.2	5.0	5.7	<5.7%
Urea	37	79	25	<50mg/dL
Creatinine	0.7	2.5	1.0	F=0.5-0.9; M=0.7-1.2 mg/dL
Free T3	1.3	2.9	3.4	2.0-4.4 pg/mL
Free T4	1.5	1.1	1.1	0.93-1.7 ng/dL
TSH	0.47	2.2	0.23	0.27-4.2 ulU/mL
Hemoglobin	11.5	14.9	16	12-15.5g/dl
TLC	7720	8180	6300	5000-11,000/mm³
DLC(P%/L%/M%)	74/19/5	58/32/6	48/46/3	60-70/20-40/2-6
ESR	19	90	8	M: 0-9, F: 0-20
ACE	35	109	70	8- 52 U/L
IgG4	0.94	0.68	1.36	0.03-2.01 g/L
γ-globulins	2.0 (25.0)	0.6 (11.2)	2.3(30.0)	0.8-1.4 g/L (18.8%)
C-reactive protein	Negative	Negative	Negative	<5 mg/L
Rheumatoid Factor	Negative	Negative	Negative	<20 IU/mL
HbsAg	Non-reactive	Non-reactive	Non-reactive	Non-reactive
Anti-HCV	Non-reactive	Non-reactive	Non-reactive	Non-reactive
ANA, C-ANCA	NA	NA	Negative	Negative
CSF examination	No pus cells or organisms, 0–1 RBC/HPF, Culture sterile	Deferred due to cerebral edema	No pus cells or organisms, 2–3 RBC/HPF, Culture sterile	0–5 cells/µL, no RBC/HPF, no organisms, Culture sterile

BioFire meningitis encephalitis panel	NA	NA	No pathogens detected	
Imaging	MRI of orbits: No localizing lesion identified. CECT brain and orbits: Unremarkable	USG (whole abdomen): Grade I fatty liver with gross ascites. 2D-Echo:: Concentric LVH	MRI of orbits: Thickening of the left optic nerve noted.	

AST:Aspartate Aminotransferase; ALT: Alanine Aminotransferase; ALP: Alkaline Phosphatase; ANA:Antinuclear antibody; TSH: Thyroid Stimulating Hormone; ESR: Erythrocyte Sedimentation Rate; ACE: angiotensin-converting enzyme; HbsAg:Hepatitis B surface antigen; anti-HCV: Hepatitis C virus antibody; RBC: Red blood cells; HPF: High power field; NA: Not available; TLC:total leukocyte count; 2D Echo: 2D echocardiography: LVH:left ventricular hypertrophy; USG: Ultrasonography

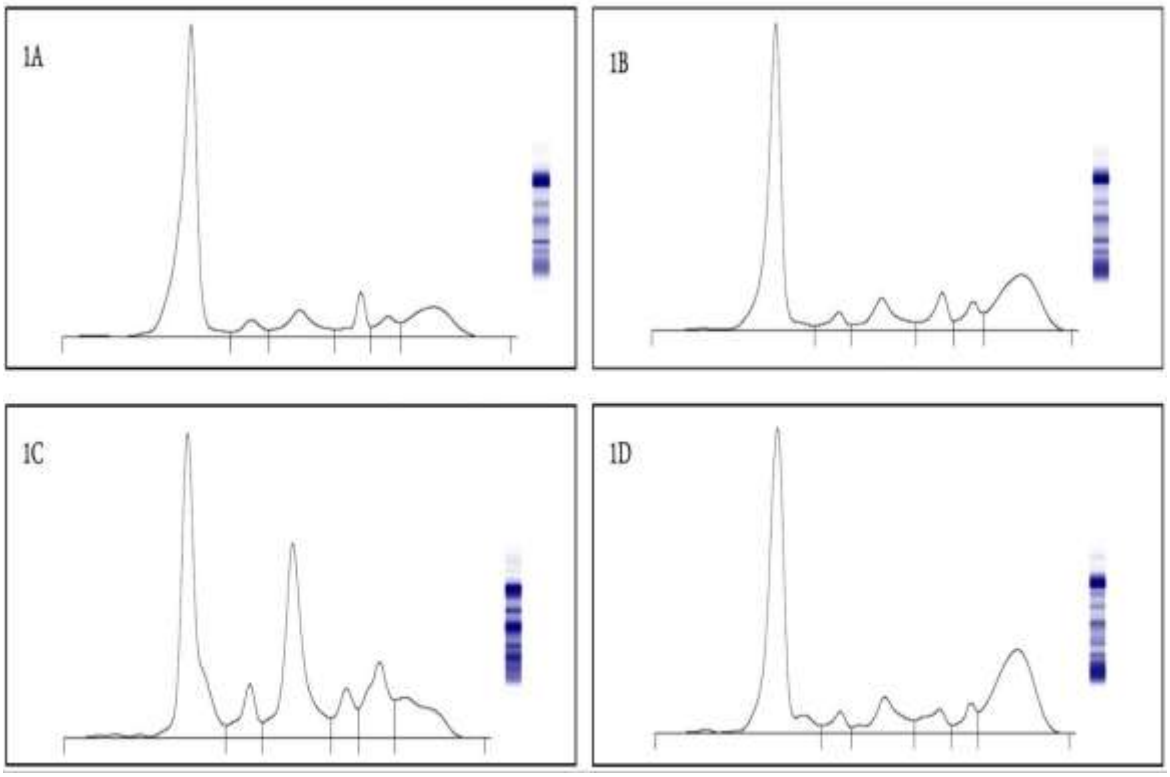

Figure 1A Normal serum electrophoretic pattern. **1B Case 1:** SPEP revealed polyclonal hypergammaglobulinemia suggestive of chronic inflammatory or autoimmune etiology. **1C Case 2:** SPEP demonstrated increased α2 and β2 fractions with distortion in β2 and γ. **1DCase 3:** SPEP showed hypergammaglobulinemia with faint β1-region distortion, likely reflecting β-region immunoglobulin migration.

Case 2

A 54-year-old man presented with a 3.5-month history of right frontotemporal throbbing headache, lasting 2–3 hours and worsening in the evening. Eight days later, he developed binocular diplopia, right eye esotropia, proptosis, restricted ocular movements, and bilateral periorbital swelling. The headache subsequently recurred once or twice weekly. Examination revealed visual acuity of 6/24 (right) and 6/12 (left), anisocoria (right<left), reduced trigeminal (V1–V3) sensation, right naso-orbital swelling, and an otherwise unremarkable motor examination.

Laboratory investigations revealed a normal total leukocyte count (8,180/mm³) and an elevated erythrocyte sedimentation rate (ESR; 90 mm/h). CRP, RF, and hepatitis B and C serology were negative. Serum angiotensin-converting enzyme (ACE) was elevated (109 U/L), whereas serum IgG4 was within the normal range (0.68 g/L) (Table 1). CSF examination was deferred because of cerebral edema. SPEP demonstrated increased α1, α2 and β2 fractions with mild distortion in β2 and γ (Figure 1c). 2D echocardiography showed concentric LV hypertrophy. USG (whole abdomen) grade I fatty liver with gross ascites. Based on the clinical presentation, a diagnosis of orbital apex syndrome was made. Nicardipine and Sobesis were prescribed, and the patient was referred to a tertiary multidisciplinary center for further evaluation and management. Patients's follow-up information and a definitive etiological diagnosis were not available. Consequently, the underlying etiology of the OAS could not be established. However, SPEP contributed meaningful adjunctive information by narrowing the differential diagnosis and supporting the overall clinical evaluation.

Case 3

A 45-year-old male, tobacco chewer with no known comorbidities, presented with 1 month history of holocranial headache followed by horizontal diplopia and mild diminution of vision in the left eye. The diplopia shows maximum separation of images on left gaze, suggesting left lateral rectus weakness. Neurological examination revealed isolated left abducens palsy, with visual acuity 6/6 in the right eye and 6/9 in the left eye with mild impairment of color vision, while pupils, visual fields, and the rest of cranial nerves were normal. Motor, sensory, cerebellar, and systemic examinations were unremarkable, and there were no meningeal signs or long-tract deficits.

CBC revealed a TLC of 6,300/mm³. Serum ACE was 70 U/L, and IgG4 was 1.36 g/L. Serological testing was negative for HBsAg and anti-HCV, while anti-HBc was positive. Antinuclear antibody (ANA) testing by indirect immunofluorescence was negative. CSF microscopy and culture were unremarkable, with negative AFB smear. CSF cytology was negative for malignant cells (Table 1). Bacterial and fungal cultures, as well as the BioFire® FilmArray® Meningitis/Encephalitis (ME) Panel, were negative. SPEP showed hypergammaglobulinemia with faint β1-region distortion. MRI brain showed thickening of the left optic nerve.

Discussion

Serum protein electrophoresis is a simple, reliable, and accurate technique used to separate serum proteins [8]. The present study findings identified distinctive pathological electrophoretic patterns observed in three rare cases of OAS: one patient showed a pattern indicative of acute inflammatory response, one exhibited polyclonal hypergammaglobulinemia and one with chronic granulomatous process.

The first case involved a 45-year-old woman presenting with clinical features consistent with OAS. The diagnosis of OAS was made only after correlating the clinical picture with SPEP, CSF analysis, and a negative autoimmune workup, while initial brain and orbital imaging was inconclusive and failed to demonstrate definitive localizing findings. Further, In the context of etiology, in our patient, SPE demonstrated polyclonal hypergammaglobulinemia (2 g/L), a pattern suggestive of an underlying inflammatory or autoimmune condition due to increased immunoglobulin production, predominantly IgG type [7]. Previous reports have identified IgG4-related disease as a recognized autoimmune cause of OAS, albeit, normal serum IgG4 levels made this diagnosis less likely in our patient [9]. Nevertheless, polyclonal hypergammaglobulinemia and the favorable response to intravenous immunoglobulin support an underlying immune-mediated etiology unrelated to IgG4-related disease.

In our second case, SPE revealed a predominantly acute-phase reactant profile, with elevated α1-globulin (0.3 g/L) and α2-globulin (1.4 g/L) fractions, a normal γ-globulin fraction (0.6 g/L), and hypoalbuminemia (1.8 g/L). During acute inflammatory states, increased hepatic synthesis of acute-phase reactants elevates the α1- and α2-globulin fractions, while cytokine-mediated suppression of albumin synthesis results in hypoalbuminemia [7]. Albeit, for this patient, elevated ACE level also raised the possibility of an underlying granulomatous or systemic/hepatic condition. Additionally, a normal CBC and absence of monoclonal protein on SPE excluded plasma cell dyscrasia–associated etiologies. Together, these findings explain the characteristic inflammatory SPE profile observed in our patient, supporting an inflammatory origin.

For the third case, SPEP demonstrated hypergammaglobulinemia with faint β1-region distortion. Hypergammaglobulinemia reflects increased immunoglobulin production associated with chronic inflammation, autoimmune, granulomatous, or chronic infectious conditions. The faint β1-region distortion is consistent with polyclonal immunoglobulin migration [7]. In the setting of negative infectious studies, negative ANA, normal serum IgG4 levels, and MRI findings of optic nerve thickening, these findings were compatible with an inflammatory granulomatous process, supporting the provisional diagnosis of neurosarcoidosis [10].

The cases in this series reflect the diagnostic heterogeneity of OAS. Case 1 lacked biopsy confirmation, Case 2 relied on a referral diagnosis, and Case 3 remained provisional neurosarcoidosis. This variability mirrors the diagnostic challenges encountered in clinical practice, where obtaining definitive tissue diagnosis is often challenging because of the anatomical location and the urgency of initiating treatment. Further, the collective findings of this case series illustrate that SPE provided valuable information by identifying distinct electrophoretic patterns of underlying inflammatory, vascular, and immune-mediated processes when conventional imaging alone was insufficient to establish the systemic etiology. Accordingly, the SPE findings should be interpreted as supportive rather than diagnostic and integrated with the patient's clinical presentation, laboratory investigations, and imaging findings. Given the rarity of OAS and with the limited literature available, this case series is the first to highlight the potential role of SPE as an adjunctive investigation in its evaluation to our knowledge. Nevertheless, the small sample size and the absence of definitive etiological confirmation in some cases limit the generalizability of these observations. Larger prospective studies are warranted to validate these findings and better define the diagnostic value of SPE in patients with OAS. In conclusion, integrating SPE into the diagnostic workup of patients with OAS, may facilitate earlier etiological diagnosis, prompt targeted investigations, and timely initiation of appropriate therapy.

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CONSENT: The patients provided their written informed consent to participate in this study and for the publication of any potentially identifiable images or data included in this article in accordance with the 1964 Helsinki declaration and its later amendments.

DATA AVAILABILITY STATEMENT The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS Singh S identified the cases and prepared the initial draft of the manuscript. Sharma M conceived the idea, supervised the entire study, contributed to manuscript drafting and critically revised the manuscript. Mahajan B provided intellectual content and critically revised the manuscript. Sharma J helped in manuscript writing and provided valuable clinical insights. Sehrawat R coordinated with the patients and assisted in taking a detailed clinical history. Cheteny C contributed to extended clinical workup and investigations. Singh M helped in compilation of data. All authors reviewed and approved the final manuscript.

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Quiz Section!!

Question 1

Lipoprotein electrophoresis using agarose gel shows intense staining at the beta and pre-beta positions. Which WHO classification of dyslipidemia is most appropriate?

1. Type I
2. Type IIa
3. Type IIb
4. Type IV
5. Type V

Question 2

A serum sample with a free glycerol concentration of 23 mg/dL yielded a triglyceride value of 442 mg/dL when measured using a non-glycerol-blanking method. What would the triglyceride value (mg/dL) be if measured using a glycerol-blanking method?
(Molecular weights: Oleic acid = 282, Glycerol = 92).

1. 196
2. 208
3. 221
4. 239
5. 254

Contributed by:

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Professor of Clinical Analysis and Molecular Biology, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo; Member APFCB Committee-Communication & Publications

Answer Section!!

Answer for question 1

3: Type IIb

Lipoprotein electrophoresis is a valuable tool for visualizing lipid distribution. The Fredrickson classification (formerly the WHO classification) categorizes lipid disorders based on the electrophoretic pattern of lipoproteins. The pattern described, with intense staining at both the beta and pre-beta positions on agarose gel electrophoresis, indicates an elevation of both LDL and VLDL:

- Type I: Elevation of chylomicrons (indicated by a dense band at the origin).
- Type IIa: Elevation of LDL (indicated by a dense band at the beta position).
- Type IIb: Elevation of both LDL and VLDL (indicated by dense bands at both the beta and pre-beta positions).
- Type IV: Elevation of VLDL (indicated by a dense band at the pre-beta position).
- Type V: Elevation of both chylomicrons and VLDL (indicated by bands at the origin and the pre-beta position).

Since the electrophoresis shows strong bands at both the beta and pre-beta positions, this is characteristic of Type IIb hyperlipidemia.

Note: Based on the Fredrickson classification, this pattern is categorized as Type IIb. In modern clinical practice, this condition is typically referred to as combined hyperlipidemia.

Answer for question 2

3. 221 mg/dL

To obtain an accurate triglyceride (TG) level, it is necessary to correct for endogenous free glycerol, which interferes with standard TG measurement methods. In clinical laboratories, this is performed using the glycerol-blanking method. According to international clinical laboratory standards, serum triglyceride concentrations are reported as triolein equivalents.

1. Calculate the molecular weight of Triglyceride:
For the purpose of this calculation, TG is assumed to be triolein, which consists of one glycerol molecule (MW = 92) and three oleic acid molecules (MW = 282). During esterification, three water molecules (MW = 18 x 3 = 54) are removed.

MWTriolein = 92 + (282 x 3) - 54 = 92 + 846 - 54 = 884

2. Convert free glycerol to its triglyceride equivalent:
The ratio of the molecular weight of TG to glycerol is 884 / 92.
Therefore, 23 mg/dL of free glycerol contributes the following amount of the measured triglyceride value:

23 mg/dL x (884/92) = 221 mg/dL

3. Calculate the true triglyceride value:
Subtract the free glycerol equivalent from the initial measured value:

True TG = 442 mg/dL - 221 mg/dL = 221 mg/dL

The triglyceride value measured by the free glycerol-eliminated method is 221 mg/dL.

Beautiful Terraced Rice-Fields in China

Contributed Dr. Tan It Koon

Rice is the staple food of Asia and part of the Pacific. Over 90 percent of the world's rice is produced and consumed in the Asia-Pacific Region. Ideally, land used for rice plantation is flat with good irrigation. However, in many rice growing countries, large areas are hilly or mountainous. Ingenious and resourceful local farming community turned the sloping areas into productive terraced farming fields' by cutting flat areas along the slope of hills and mountains in the form of graduated terraces to grow crops on all sides of hills and mountains. Though labour-intensive, the method has been employed effectively to maximize arable land area in variable terrains and to reduce soil erosion and water loss.

Besides rice, other crops with varying time for maturity and harvest are also cultivated at the same time, or at other times. Algae with bright colour grow on the surface of the still and shallow water in some of the terraces. These contribute to the fascinating and changing view of multi-coloured patches in the fields that appear like a modern abstract painting consisting of lines, geometrical shapes and colours. In addition to their important primary role of rice and other crop production, the terraced fields are beginning to help generate additional income because of the unusual views they offer to city dwellers. The spectacular scenic beauty of some of these areas in the more remote parts of the Philippines, China and Vietnam are attracting the attention of avid travellers in more recent times. Photographs and video recordings captured on hand-phones and posted on the internet have helped publicize the scenic beauty of the terraced rice-fields which are located at relatively undeveloped and inaccessible areas.

With increasing demand for eager's visitors, they are becoming well-known and popular scenic spots and unique attractions for nature-loving tourists, artists and photographers. Roads and other relevant facilities for tourists are being developed to facilitate access to such places. Most spectacular. The fields are mainly divided into 3 scenic spots including Bada, Laohuzui (the Mouth of Tiger) and Duoyi Tree areas. All the terraced fields are situated on the hills with slope gradient varying from 15 to 75 degree. The highest mountain has about 3000 terraced fields from the bottom to the top. This painting is inspired by my visits to the terraced rice-fields in China and captures my impression of the beauty and magnificence of the hilly areas which consist of numerous long irregular strips of land carved closely in parallel on slopes. Colour of the crops, algae, and the reflection of changing colour of the sky from the shallow water in each enclosed elongated strips of land give rise to an interesting jigsaw puzzle landscape painting with ever-changing variation in the shades and colours of its constituent pieces.