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CONSENSUS STATEMENT

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EBCP Expert consensus statement on basic qualifications and competencies for clinical perfusionists in Europe developed in collaboration with EACTS and EACTAIC: Knowledge, skills, and competencies required for contemporary clinical perfusion practice

Adrian Bauer[1,*] (Chairperson); Alexander Wahba[2,3] (Vice-Chairperson); Gudrun Kunst[4,5] (Vice-Chairperson); Kyriakos Anastasiadis[6]; Friedhelm Beyersdorf[7,8]; Maria A. Bruño[9]; Gerdy Debeuckelaere[10]; Deborah Halle[11]; Marloes van Hoeven[12]; Jan Hofland[13]; Christian Klüß[14]; Slavko Kulic[15]; Guillaume Lebreton[16]; Rantanen Markku[17]; Mona Momeni[18,19,20]; Gianluca Paternoster[21,22]; Marco Ranucci[23]; Stephen Robins[24]; Normunds Sikora[25]; Filip De Somer[26]; Marc Vives[27,28]; Volkmar Falk[29,30,31]; Fabio Zanella[32]; Milan Milojevic[33,34]; EBCP/EACTS/EACTAIC Scientific Document Group

[1]Department of Cardiovascular Perfusion, Evangelic Heart Centre Coswig, Coswig, Germany
[2]Department of Cardio-Thoracic Surgery, St Olavs University Hospital, Trondheim, Norway
[3]Department of Circulation and Medical Imaging, Norwegian University of Science and Technology, NTNU, Trondheim, Norway
[4]Department of Anaesthetics and Pain Therapy King's College Hospital NHS Foundation Trust, London, United Kingdom
[5]School of Cardiovascular and Metabolic Medicine & Sciences, King's College London, United Kingdom
[6]Cardiothoracic Department, Aristotle University of Thessaloniki School of Medicine, Greece
[7]Department of Cardiovascular Surgery, University Hospital Freiburg, Germany
[8]Medical Faculty of the Albert-Ludwigs-University Freiburg, Germany
[9]Department of Perfusiology, Consorcio Hospital General Universitario de Valencia, Spain
[10]Perfusion Department, Antwerp University Hospital, Edegem, Belgium
[11]Department of Cardiothoracic and Vascular Surgery, Aarhus University Hospital, Aarhus, Denmark
[12]Department of Extracorporeal Circulation, Catharina Hospital, Eindhoven, The Netherlands
[13]Department of Anesthesiology, Radboud University Medical Center, Radboud Institute for Health Sciences, Nijmegen, The Netherlands
[14]Department of Perfusiology and Technical Medicine, Heart and Diabetes Centre North Rhine-Westphalia, Germany
[15]Department of Perfusion, University Clinical Center of Serbia, Belgrade, Serbia
[16]Department of Cardiac Surgery, Pitié Salpetrière University Hospital, Sorbonne University, Paris, France
[17]Department of Anaesthesia, Tampere University Hospital, Tampere, Finland
[18]Department of Anesthesiology, Cliniques Universitaires Saint Luc, Brussels, Belgium
[19]Institute of Experimental and Clinical Research, UCLouvain, Brussels, Belgium
[20]Institute of Neuroscience, UCLouvain, Brussels, Belgium
[21]Department of Health Sciences, University of Basilicata, Potenza, Italy
[22]Cardiovascular Anaesthesia and ICU, San Carlo Hospital, Potenza, Italy
[23]Department of Cardiovascular Anesthesia and ICU, IRCCS Policlinico San Donato, Milan, Italy
[24]Department of Perfusion, Royal Wolverhampton NHS Trust, Wolverhampton, UK
[25]P. Stradins Clinical University Hospital, Riga Stradins University, RSU Red Cross Medical College, Riga, Latvia
[26]Heart Centre University Hospital Ghent, Ghent, Belgium
[27]Department of Anesthesia & Critical Care, Clínica Universidad de Navarra, Pamplona, Spain
[28]Instituto de Investigación Sanitaria de Navarra (IdiSNA), Pamplona, Spain
[29]Department of Cardiothoracic and Vascular Surgery, Deutsches Herzzentrum der Charité, Charité University Medicine Berlin, Berlin, Germany
[30]DZHK (German Center for Cardiovascular Research), Berlin, Germany
[31]Department of Health Science and Technology, Swiss Federal Institute of Technology, Zurich, Switzerland
[32]Perfusion Unit, Hospital University of Padova, Padua, Italy
[33]Department of Cardiac Surgery and Cardiovascular Research, Dedinje Cardiovascular Institute, Belgrade, Serbia
[34]Department of Cardiac Surgery, University Hospital Zurich, University of Zurich, Zurich, Switzerland

*Corresponding author. Department of Cardiovascular Perfusion, Evangelic Heart Centre Coswig, Lerchenfeld 1, 06869 Coswig, Germany. Tel: +49-34903-49175; fax: +49-34903-49359; e-mail: Adrian.Bauer@ebcp.eu (A. Bauer).

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EBCP/EACTS/EACTAIC Document Reviewers: David Reineke[1], Matthias Siepe[1], Johan Bence[2], Martin Czerny[3], Hansjoerg Jenni[4], Marcus Lance[5], Sven Maier[6], Frank Merkle[7], Juan Blanco Morillo[8], Aleksandar Nikolic[9], Francesco Onorati[10], Prakash Punjabi[11,12], Enrico Squiccimarro[13,14], Miguel Sousa-Uva[15]

From: [1]Department of Cardiac Surgery, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland; [2]Department of Anaesthesiology and Intensive Care, University Hospitals of Leicester NHS Trust, Leicester, United Kingdom; [3]Department of Cardiovascular Surgery, University Heart Center Freiburg-Bad Krozingen, Faculty of Medicine, Albert Ludwigs University Freiburg, Freiburg, Germany; [4]Department of Cardiac Surgery, University of Bern, University Hospital Bern, Bern, Switzerland; [5]Department of Anesthesiology, Aga Khan University Hospital Nairobi, Nairobi, Kenya; [6]Department of Cardiovascular Surgery, Heart Center, University of Freiburg, Freiburg, Germany; [7]Foundation Deutsches Herzzentrum Berlin, Berlin, Germany; [8]ECLS Care and Perfusion Unit, Cardiac Surgery Department, University Hospital Virgen de la Arrixaca, Murcia, Spain; [9]Department of Cardiovascular Surgery, Acibadem Sistina Hospital, Skopje, North Macedonia; [10]Department of Cardiac Surgery, S. Chiara Hospital, APSS PA of Trento, Trento, Italy; [11]Department of Cardiothoracic Surgery, Hammersmith Hospital, Imperial College Healthcare NHS Trust, London, United Kingdom; [12]National Heart and Lung Institute, Imperial College, London, United Kingdom; [13]Division of Cardiac Surgery, Department of Medical and Surgical Sciences, University of Foggia, Foggia, Italy; [14]Cardio-Thoracic Surgery Department, Heart & Vascular Centre, Maastricht University Medical Centre, Maastricht, The Netherlands; [15]Department of Cardio-thoracic Surgery, Hospital de Santa Cruz, Carnaxide, Portugal.

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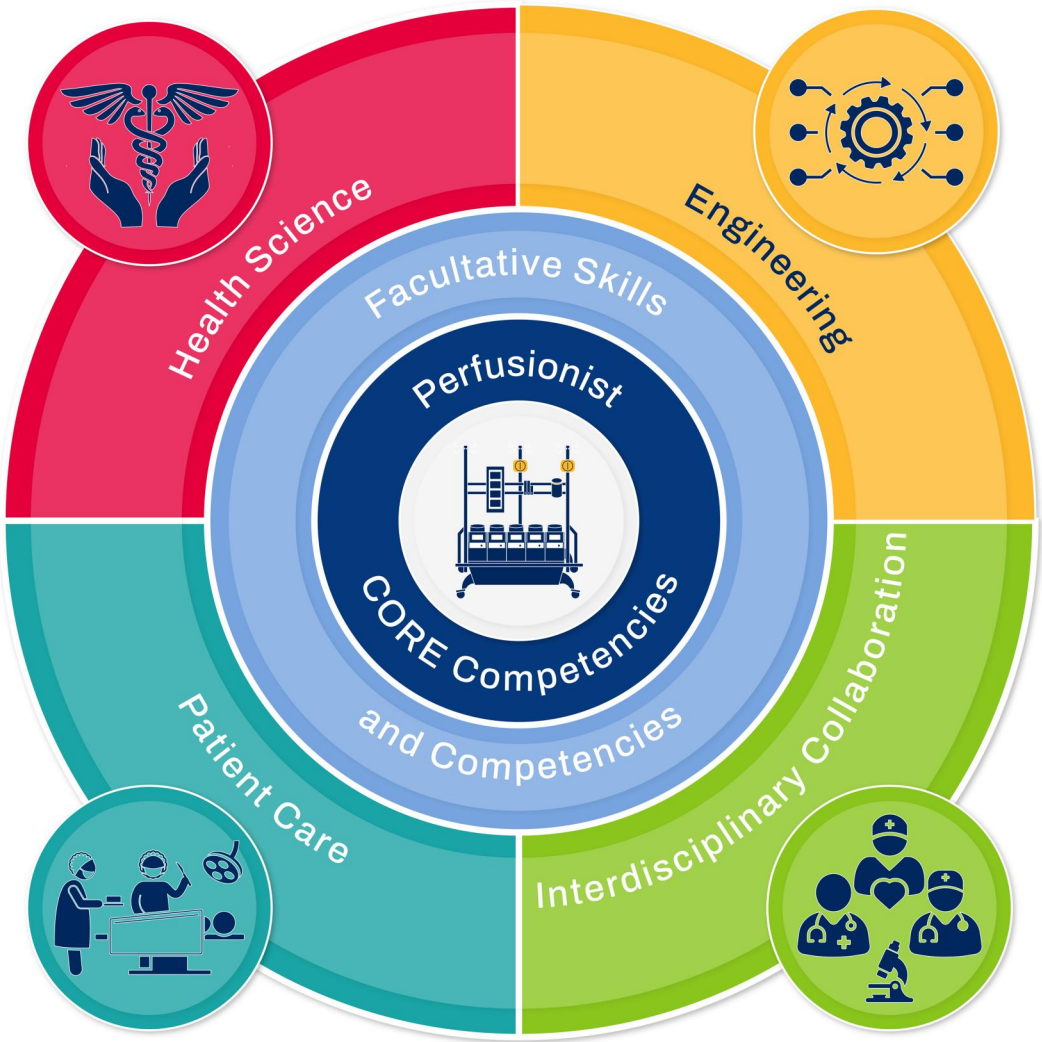
Graphical abstract



Central Illustration. Core Qualifications and Competency Framework for Clinical Perfusionists.

Abstract

Clinical perfusionists manage and optimize extracorporeal circulation as well as physiological and metabolic stability, to support positive patient outcomes under artificial physiological conditions, such as cardiopulmonary bypass, extracorporeal membrane oxygenation, and other extracorporeal circulation systems. Despite the central role of the profession in patient safety and surgical outcomes, clinical perfusion remains inconsistently defined, regulated, and recognized across Europe. In response to these challenges, the European Board of Cardiovascular Perfusion, together with the European Association for Cardio-Thoracic Surgery and the European Association of Cardiothoracic Anaesthesiology and Intensive Care, convened a multidisciplinary task force to develop a unified expert consensus on the minimum academic education, supervised clinical training, and continuing professional development for safe and independent practice. It defines essential technical competencies, such as the operation of heart-lung machines and mechanical circulatory support devices, alongside critical non-technical skills in decision-making, communication, and interdisciplinary collaboration. The document also introduces a tiered framework to classify perfusionists by experience level and proposes mechanisms for certification and recertification through the European Certificate in Cardiovascular Perfusion. Furthermore, the statement highlights the importance of structured quality assurance programs, simulation-based education, and incident reporting systems in advancing perfusion safety and clinical effectiveness. A harmonized European approach is urgently needed to ensure consistent training standards, enhance workforce mobility, and support formal recognition of clinical perfusion as a regulated healthcare profession. This consensus aims to serve as a benchmark for national regulatory efforts and future professional development across Europe.

Keywords: Clinical perfusionists; education and training; professional recognition; cardiovascular perfusion; certification; European Certificate in Cardiovascular Perfusion; national recognition; medical profession; EBCP/EACTS/EACTAIC Qualifications Framework.

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ABBREVIATIONS AND ACRONYMS

ABCP	American Board of Cardiovascular Perfusion
ANZCP	Australian and New Zealand College of Perfusionists
COI	Conflict of interest
CPB	Cardiopulmonary bypass
EACTAIC	European Association of Cardiothoracic Anaesthesiology and Intensive Care
EACTS	European Association for Cardio-Thoracic Surgery
EBCP	European Board of Cardiovascular Perfusion
ECC	Extracorporeal circulation
ECCP	European Certificate in Cardiovascular Perfusion
ECTS	European Credit Transfer and Accumulation System
HLM	Heart-lung machine
ICU	Intensive care unit

1. INTRODUCTION

Clinical perfusionists are highly trained healthcare professionals who play a pivotal role within the cardiac surgical team and other multidisciplinary teams involved in procedures requiring extracorporeal circulation (ECC) support. A central responsibility is the operation and management of the heart-lung machine (HLM), which temporarily replaces the functions of the heart and lungs during operations. This task demands technical precision and the ability to make rapid, evidence-based clinical decisions to preserve physiological stability and manage intraoperative challenges.

By ensuring uninterrupted circulation and oxygenation during circulatory support, perfusionists enable the safe execution of some of the most complex and invasive procedures in modern medicine,[1] contributing markedly to favourable surgical outcomes and enhanced postoperative recovery.[2] As integral members of the cardiac surgical team, perfusionists collaborate closely with surgeons, anaesthesiologists, and allied health professionals.[3-8] Specialized knowledge, sound clinical judgement, and the ability to respond under pressure make this profession indispensable to the safety and effectiveness of ECC procedures.

Although the professional background of clinical perfusionists is globally diverse, encompassing healthcare practitioners, engineers, and technicians with specialized medical training, the European context is particularly complex due to varying regional policies and historical frameworks.[9-11] Although most countries across Europe follow the international model of non-physician clinical perfusionists, others, such as those in Eastern Europe, Finland, and France, include physicians in this role. Moreover, in Italy and Portugal, perfusion responsibilities are often held by polytechnic-trained physiotechnologists, reflecting additional variability in educational pathways and scope of practice.

Moreover, despite bearing substantial clinical responsibility, clinical perfusionists remain formally unrecognized in many European countries. This lack of regulatory status creates significant challenges, including inconsistencies in education and certification, limited opportunities for professional development, and barriers to cross-border mobility. Hence, a harmonized European framework for the formal recognition of clinical perfusion as a healthcare profession is urgently needed. Advancing this goal requires a unified definition of the profession and alignment among leading representative professional societies.[10] Recognition must be grounded in clinical expertise, shared training standards, ethical principles, regulatory structures, and accreditation mechanisms.

Although support from policymakers has been limited, clinical perfusion in Europe has made substantial progress towards professionalization through self-directed initiatives. The development of structured training programs, certification pathways, and dedicated professional societies has helped shape a more cohesive framework for the field. Since the 1990s, the European Board of Cardiovascular Perfusion (EBCP) has issued the European Certificate in Cardiovascular Perfusion (ECCP), serving as a standardized benchmark for assessing competence across countries.[4,10-13] The certification committee of the EBCP was founded on 23–24 November 1991, together with the EBCP. The first certification took place on 3 July 1995. The EBCP accreditation committee (re)accredits training centres and universities at regular intervals, thereby ensuring standardised training content across all centres.

The certification of individual professionals and the accreditation of study programmes both aim to promote consistency in clinical practice and contribute to the delivery of high-quality care throughout Europe. However, further harmonization of training and practice standards will require a unified position from leading European professional societies. Formal recognition of clinical perfusion as a regulated healthcare profession grounded in a clearly defined education and scope of practice will more likely improve patient outcomes.

To support these critical objectives, the EBCP, in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS) and the European Association of Cardiothoracic Anaesthesiology and Intensive Care (EACTAIC), has developed this expert consensus document. It defines the minimum standards of knowledge, skills, and competencies required of clinical perfusionists in contemporary practice, intending to harmonize training pathways and support the formal recognition of clinical perfusion as a regulated profession. Whereas previous joint guidelines have provided general recommendations on perfusionist training,[14] inconsistent national regulations remain a significant barrier to their widespread implementation. This consensus statement presents a unified, profession-driven framework that defines core qualifications and expectations, serving as a catalyst to align training standards, enhance mobility, and accelerate professional recognition across Europe.[10]

2. METHODOLOGY

To provide in-depth insights and support educational, policymaking, and professional activities, an expert task force was convened to comprehensively define the minimal standards for theoretical knowledge, skills, and competencies required to certify clinical perfusionists in adult cardiac surgery. This task force, composed of leading professionals in the field and experts in developing clinical practice documents, was appointed by the leadership of the EBCP, the EACTS, and the EACTAIC following the procedures outlined in the EACTS methodology manual for clinical practice documents.[15,16] The involved associations insisted on diversity and transparency in task force composition, ensuring full disclosure of any industrial or external affiliations. All task force members were required to disclose conflicts of interest (COIs) at the project's initiation and upon any relevant changes throughout the drafting process. Following the finalization of the scope and content of the project, members were assigned to draft specific sections, with 1 representative each from EBCP, EACTS, and EACTAIC. Each representative subsequently developed their section and conducted a rapid, systematic literature review using the PICOT (Population, Intervention, Comparison, Outcome, Time) framework to gather the most relevant and up-to-date data. Searches were conducted in MEDLINE (via PubMed), Embase, and the Cochrane Library, and grey literature was screened from relevant professional societies and regulatory bodies (e.g., EACTS, EACTAIC, EBCP, Society of Thoracic Surgeons, national perfusion councils/registries, and statutory regulators). Searches targeted publications relevant to education and training standards, scope of practice, core knowledge and skills, quality assurance, incident reporting, and legal/professional responsibilities for clinical perfusionists. This document focuses exclusively on adult cardiac surgery, excluding studies that were not published in the English language. All sections were written collaboratively by task force members, with expert consensus statements developed through structured meetings and discussions. According to EBCP/EACTS/EACTAIC COI policies, members were required to report any COI changes immediately before discussions and voting. Only members without relevant COIs participated in decision-making. An anonymous voting mechanism was implemented to ensure broad participation and consensus, allowing members to approve or disapprove of drafted statements, figures, and algorithms and provide additional comments. A consensus threshold of at least 75% agreement was required for overall proposal approval, with a minimum participation rate of 80% to validate the results. In this project, every individual statement reached a minimum of 90.5% agreement. Given the significant variations in education

and resources across Europe, the minimal standard was designed to reflect a European perspective. The final draft underwent internal validation by the writing committee and external review by anonymous reviewers selected by the journal's editor in collaboration with the governing bodies of the involved societies.

3. EVOLUTION OF CARDIOPULMONARY BYPASS AND PERFUSION AS A PROFESSION

The evolution of the earliest conceptualization of ECC began with Julien Jean César Le Gallois in 1814 in France.[17] It was continued by Maximilian von Frey's early prototype of the HLM, developed at the University of Leipzig in 1885. This pioneering work laid the groundwork for future breakthroughs in cardiopulmonary bypass (CPB). However, it was not until 1953 that John Gibbon performed the first successful human CPB in Philadelphia, a milestone that marked the beginning of modern heart surgery (**Figure 1**). John Gibbons' wife, Mary Gibbons, was the first person to carry out the tasks involved in CPB, thereby becoming the world's first perfusionist.

Today, millions of patients worldwide undergo successful procedures using CPB.[17,18] Between the 1970s and 1990s, cardiac surgery made remarkable advancements that profoundly shaped perfusion technology and modern clinical practice. Key developments during this era included the introduction of advanced oxygenators, more sophisticated pump systems, the introduction of biocompatible coatings, improved temperature regulation, enhanced intraoperative monitoring, and the adoption of blood conservation techniques. These innovations significantly enhanced the safety and efficacy of CPB. The developments in certain features of minimally invasive extracorporeal circulation have contributed to the refinement of CPB techniques. These elements are likely to account for the clinical benefits observed in modern perfusion. These advancements were integrated into a technique associated with reduced side effects and improved outcomes.[19-21] Research on ECC increased significantly during these years, and this field developed into an independent area of research. It was not only new devices and disposable items that were needed, but also in-depth knowledge from users, namely, well-trained perfusionists.

As cardiac procedures became increasingly complex, along with advancements in mechanical circulatory support and the growing adoption of transcatheter interventions for managing structural heart diseases, the role of the clinical perfusionist evolved significantly. No longer limited to operating the HLM, perfusionists have become integral members of various multidisciplinary cardiac teams. Nowadays, perfusionists are working increasingly outside their traditional cardiac surgical field. For example, they work in intensive care units (ICUs) with extracorporeal membrane oxygenation systems and are involved in various types of organ perfusions. They also form part of the multidisciplinary team in oncology, performing, for instance, hyperthermic intraperitoneal chemotherapy.[22,23]

This expanding scope and responsibility led to the establishment of formal academic education pathways, structured training programs, and professional certification systems worldwide.

4. PERFUSION EDUCATION AND PRACTICE ACROSS THE WORLD

The United States of America has played a pivotal role in shaping the profession of clinical perfusion. It was the first country to implement standardized structures for defining the professional profile of perfusionists.[24] Founded in 1964, the American Society of Extracorporeal Technology is the oldest professional society for clinical perfusionists. Its primary objective was to establish certification and professional recognition. In 1975, it supported the establishment of the independent American Board of

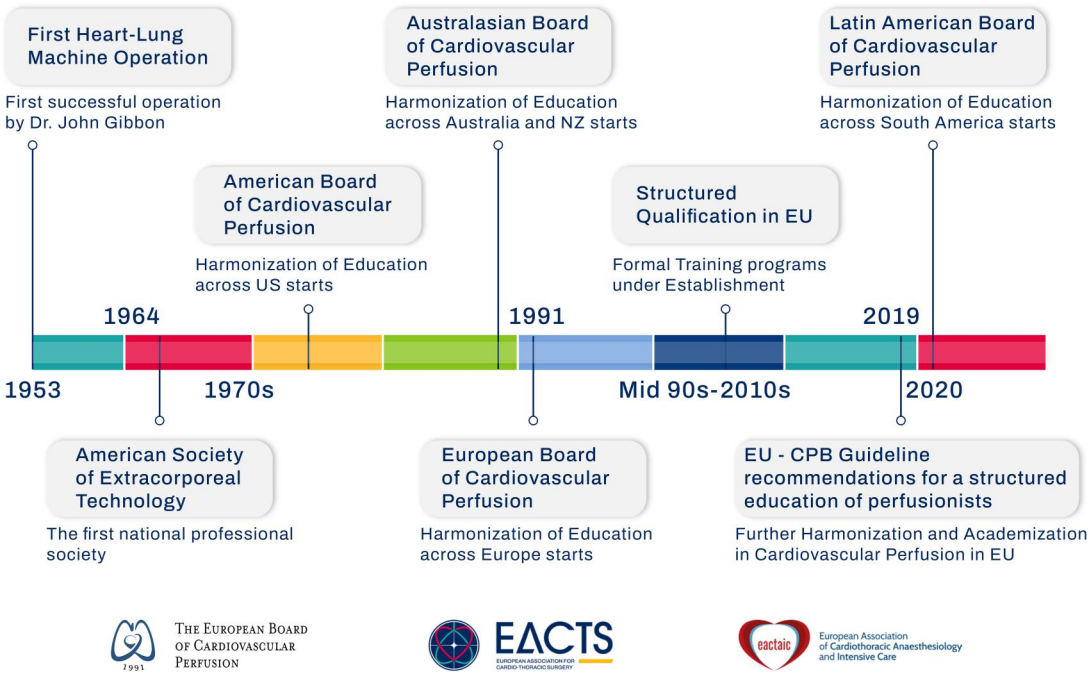

Figure 1. Milestones in the Establishment of the New Profession of Clinical Perfusionist. CPB indicates cardiopulmonary bypass; EU, European Union; US, United States.

Cardiovascular Perfusion (ABCP), which has been certifying perfusionists in the United States ever since. Today, a state license is typically required to practice as a clinical perfusionist in the United States. Although many states have their own licensing processes, only 19 of the 50 states currently recognize state licensure. In these states, ABCP certification is usually a prerequisite.[25]

In Australia and New Zealand, perfusionist organizations initially began at the state level. By 1982, local societies had consolidated to form the Australian and New Zealand College of Perfusionists (ANZCP). The Australian Board of Cardiovascular Perfusion was established in 1989 to oversee formal education and certification. In 1993, the Structured Course in Clinical Perfusion was launched. Recognizing the need for tertiary-level education, the board established a collaboration with Swinburne University of Technology in 2005, which was later discontinued. Since 2021, the Medical University of South Carolina (Columbia, SC, USA) has provided online education for trainees. In 2025, Monash University and the Victorian Heart Hospital will launch a new master's level course, with ANZCP-certified perfusionists eligible to upgrade their qualifications. Course graduates will be eligible to sit for the ANZCP certification exam.

Established over 30 years ago, the Canadian Society of Clinical Perfusion (CSCP) is the national body for clinical perfusionists in Canada. It promotes the profession through advocacy, education, and setting standards. Since the early 1990s, the CSCP has offered the Canadian Certification Examination in Clinical Perfusion, which is recognized nationwide as the primary qualification for practising clinical perfusionists, because there is no provincial licensure. Most employers require CSCP certification for employment. Candidates must complete an accredited Canadian perfusion programme, typically at a master's or certificate level, with a focus on biomedical sciences and clinical training. There is a growing trend towards more master's-level education to enhance competency. The CSCP supports educational development and ongoing professional growth through continuing education. As of 2024, there were more than 375 certified perfusionists in membership, with certification renewal based on clinical activity and professional development.[26]

In Latin America, the development of cardiovascular perfusion is closely linked to the progress of cardiac surgery in North America. The first successful operation using CPB in the region was performed by Dr Hugo Felipozzi in São Paulo, Brazil, in 1957. The Latin American Perfusion Association was founded in 2016 to support regional integration and professional development. Latin America is divided into 5 regions: (1) Northern Region (Mexico); (2) Central America and Caribbean (Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Dominican Republic, Cuba, Trinidad and Tobago, Jamaica, Puerto Rico); (3) Andean Region (Venezuela, Colombia, Ecuador, Peru, Bolivia): (iv) Southern Cone (Chile, Argentina, Uruguay, Paraguay); and (5) Southeast Region (Brazil). Training and accreditation vary significantly by country and are influenced by local regulations. Perfusionists come from diverse backgrounds, including medicine, nursing, respiratory therapy, biomedical engineering, and biology. In 2020, the Latin American Board of Cardiovascular Perfusion was established to harmonize accreditation and issue the *Perfusionista Clínico Certificado*. Since 2023, only graduates from university-level programs are eligible for the certification exam. Despite the absence of official recognition in many national health systems, progress continues towards establishing perfusion as a regulated profession.[27]

Despite efforts by organizations such as the Japanese Society of Extra-Corporeal Technology in Medicine and the Indian Association of Cardiovascular and Thoracic Anaesthesiologists to standardize training and certification, significant variation persists across Asia. Countries offer different programmes: In China, there is university-based undergraduate and postgraduate training, which requires national certification. In India, diploma, bachelor's, and master's programmes are provided. In Japan, perfusion is included within the scope of clinical engineering, and certification is overseen by the Japanese Society of Extracorporeal Technology in Medicine. In South Korea, medical or nursing degrees are required, and the Korean Society regulates the profession. Singapore offers postgraduate training regulated by the Medical Council, while Thailand provides bachelor's level training certified by the Medical Technology Council. Malaysia offers a bachelor's degree in Cardiovascular Technology certified by the Malaysian Society, and the Philippines provides training through allied health programmes with certification from the Philippine Board. In the Middle East (Saudi Arabia and the United Arab Emirates), perfusion education is at a bachelor's or master's level, with certification through local or international bodies such as the ABCP.[28-30]

Currently, no consolidated data are available for Africa except for South Africa. This fact underscores the need for further investigation and support to strengthen perfusion practice on the continent. Cardiac surgery in South Africa began with the first bypass procedure in 1959 and has been supported by specialized perfusionists since the early 1960s. Training was formalized through diplomas and degrees, and the Perfusionists Association (PASA/Perfmed), founded in 1997, now advocates for the profession, representing most perfusionists nationwide across 8 provinces. Perfusionists require a Clinical Technology degree or diploma, as well as registration with the Health Professions Council of South Africa, to qualify for high-tech clinical roles in areas such as cardiology and perfusion.[31]

For more detailed information about perfusion practice worldwide, please read the section "Perfusion in Different Countries" in the **supplementary material** and see **Table 1** for a summary of academic and certification requirements.

5. PERFUSION EDUCATION AND PRACTICE IN EUROPE

The clinical perfusionist profession in Europe is regulated by the European Commission as a self-regulating profession, with the EBCP recognized as the designated professional body.[32] The EBCP sets educational standards to ensure that clinical perfusionists possess the requisite knowledge, skills, and competencies to perform perfusion procedures safely and effectively, grounded in scientific evidence (**see supplementary material**). This is implemented through an accreditation process and the awarding of the ECCP. A survey of European universities revealed that the average content required for perfusion training, approximately 60 European Credit Transfer and Accumulation System (ECTS) credits, is insufficient to constitute a complete undergraduate programme (eg, BSc: 180+ ECTS), making perfusion education better suited to postgraduate or

Table 1. Academic Qualification Level, Certifying Bodies, and Regulatory Requirements for Clinical Perfusionists Outside Europe

Country/Region	Education Level	Certification Body	Regulation Status
United States	Bachelor's, master's, or post-baccalaureate certificate	American Board of Cardiovascular Perfusion (ABCP)	Licensure required in 19 states; ABCP certification mandatory
Australia & New Zealand	Master's degree (from 2025); Structured course (SCiP) previously	Australian and New Zealand Board of Perfusion (ANZBP)	Certification required; profession formally recognized
Latin America	Varies; increasing shift towards university-level education	Latin American Board of Cardiovascular Perfusion (LABCP)	Certification via LABCP *Perfusionista Clínico Certificado* (PCC); profession not consistently recognized
South Africa	Bachelor of Health Sciences in Clinical Technology (BHSc Clinical Technology)	Health Professions Council of South Africa (HPCSA)	Certification required
China	Undergraduate and postgraduate (medical universities)	National Certification Examination	National certification required
India	Diploma, bachelor's, or master's degree in perfusion technology	Indian Association of Cardiovascular and Thoracic Anaesthesiologists and others	Certification varies; regulations are inconsistent.
Japan	Integrated into Medical technology; specialization for clinical engineers	Japanese Society of Extra-Corporeal Technology in Medicine (JaSECT)	A clinical engineering license is mandatory
South Korea	Specialized medical technology degree plus clinical experience	Korean Society of Cardiovascular Perfusion	Certification and regulation are required
Singapore	Postgraduate program following a science/health degree	Singapore Medical Council; Society of Clinical Perfusion Scientists of Singapore	Certification required; profession regulated
Thailand	Bachelor's degree (medical technology or nursing)	Thai Medical Technology Council	Certification and standardized education are required
Malaysia	Bachelor's degree in cardiovascular technology	Malaysian Society of Perfusionists	Certification required
Canada	Post-baccalaureate certificate or master's degree	Canadian Society of Clinical Perfusion (CSCP)	Certification required; no provincial licensure

elective modules within broader degree programmes.[10] Accordingly, training duration varies across Europe, ranging from 1 to 4 years, depending on entry requirements and national contexts.

European perfusionists originate from diverse healthcare backgrounds and undergo specialized training in CPB. However, no unified European regulation currently governs the profession, and in most European countries, clinical perfusion is not yet formally recognized by national legislation.[11] Entry routes into the profession differ significantly across regions and include the following:

- **Allied Healthcare Professionals:** Many European perfusionists, particularly in Northern and Western Europe (e.g., Scandinavia, Germany, Belgium, Austria, the United Kingdom, Spain, and France), enter the field through nursing or other allied health professions.[4,11]
- **Medical Technicians and Engineers:** In countries such as Germany, Sweden, Greece, and the Netherlands, individuals with technical or engineering degrees are eligible. In Germany, engineering students can specialize in clinical perfusion in their undergraduate studies.[4,11]
- **Health Professional Technologists:** In Southern European countries, such as Italy and Portugal, perfusion is integrated into polytechnic programs with a focus on cardiovascular and physiological aspects.[11]
- **Medical Doctors:** In Eastern Europe (e.g., the Baltic States, Ukraine, and Finland), physicians, including specialists, often perform perfusion duties. However, efforts are underway to align with EBCP standards and involve non-physician healthcare professionals in perfusion training. Notably, some physicians in France also perform perfusion.[11]
- **Other Professional Backgrounds:** In countries such as the Netherlands and Greece, entry may also be granted to individuals holding degrees in biology, physics, or health sciences.

The level of academic qualification required for perfusion training also varies. Training programmes in the Netherlands, France, and Greece are delivered at the master's level and are aligned with national qualification frameworks.[4,10,11] In other countries, the entry requirement is typically a bachelor's degree, or the training itself culminates in a bachelor's qualification.

Although the EBCP has made meaningful progress in fostering harmonization across Europe, the regulation of clinical perfusionists remains fragmented and reliant on national frameworks. Formal recognition or licensure is currently established in only a limited number of countries. Nevertheless, all European Union countries, except for Austria and Estonia, are actively engaged with the EBCP in defining core standards for education and professional practice.

For more detailed information on European perfusion practice, please refer to the section "1. Perfusion in different countries 2025," in the **supplementary document** "EBCP Expert Consensus Statement on Basic Qualifications and Competencies for Clinical Perfusionists in Europe".

Consensus Table 1. The Definition of the Clinical Perfusionist Profession

• A clinical perfusionist is a healthcare professional who has received formal academic training and is part of a cardiac surgery team or any other medical team where ECC is required.
• A clinical perfusionist is responsible for performing and monitoring CPB to provide and maintain a safe and physiological environment for the patient during cardiac surgery.
• A clinical perfusionist is responsible for the technical support and operation of medical devices, including tMCS and dMCS, cell salvage/autotransfusion, organ perfusion systems for ex-vivo perfusion and normothermic extracorporeal perfusion, HIPEC, ITP, and limb perfusion.

Abbreviations: CPB, cardiopulmonary bypass; dMCS, durable mechanical circulatory support; ECC, extracorporeal circulation; HIPEC, hyperthermic intraperitoneal chemotherapy; ITP, isolated thoracic perfusion; tMCS, temporary mechanical circulatory support.

6. ESSENTIAL QUALIFICATIONS FOR CLINICAL PERFUSIONISTS

The pathway to becoming a certified clinical perfusionist in Europe involves a structured, multi-stage process that combines academic education, practical clinical training, and ongoing professional development. Candidates should complete an accredited programme with a defined perfusion-specific curriculum, gain supervised clinical experience, and demonstrate ongoing competency through regular recertification. These components are essential to ensure that perfusionists meet the high standards required for independent practice in cardiovascular procedures.

6.1 Academic Education

To qualify as a clinical perfusionist, individuals must complete a rigorous educational and training programme that ensures the acquisition of essential competencies and skills. The minimum entry requirement is typically attaining a bachelor's degree.[8] A solid foundation in biological, anatomical, physiological, mathematical, and health sciences is strongly recommended. The programme of study should be grounded in an accredited curriculum, covering core domains such as anatomy, physiology, biochemistry, pharmacology, pathology, equipment and technology, patient monitoring, clinical management, and service provision.[8,33]

To ensure adequate subject-specific preparation, it is further recommended that perfusion education comprise a minimum of 60 ECTS credits dedicated exclusively to perfusion science (see "Section *2*. The syllabus in perfusion sciences" in the **supplementary document**").[33,34] In addition to foundational qualifications, advanced or consecutive academic pathways may include specializations in extracorporeal technology, technical medicine, or clinical research—provided these programmes are accredited and aligned with perfusion competencies. Higher academic degrees can be particularly beneficial for experienced perfusionists. This is mainly true for areas such as research and specialities, such as paediatric perfusion and rhythmology, as well as perfusion department management.

These academic tracks may ultimately lead to a master's or Ph. D. degree, offering opportunities for further expertise and leadership roles within the field. The authors of this consensus paper believe that it is urgent to raise the minimum qualification level from a bachelor's to a master's degree. However, given the varying circumstances in different European countries and the fact that a bachelor's degree is not always a prerequisite for university studies, the recommendation below proposes a transition period of 5–10 years.

Consensus Table 2. Practical Training and Continuing Education Requirements for European Clinical Perfusionists

• The qualification as a clinical perfusionist must be an academic degree at least at the bachelor's level (European Qualifications Framework 6) and include at least 60 ECTS in topics exclusively designated in the EBCP perfusion syllabus.
• A master's degree, covering many required competencies for a perfusionist as a clinical scientist, should be included in all educational programmes within the next 5-10 years (European Qualifications Framework 7).

Abbreviations: EBCP, European Board of Cardiovascular Perfusion; ECTS, European Credit Transfer and Accumulation System.

6.2 Practical and clinical training

In addition to academic preparation, clinical perfusionists must undergo extensive hands-on training to develop the competencies required for independent practice. This training is typically conducted in a clinical perfusion unit within a cardiac surgery department and spans approximately 2–3 years. A core training element is the maintenance of a clinical logbook, usually provided by the EBCP, which must document a minimum of 100 supervised CPB procedures. These cases must encompass the full spectrum of clinical domains outlined by relevant professional societies, with clinical content covering the basics of perfusion in children and neonates. The clinical tutors should hold an ECCP to ensure that practical training is performed adequately.[8,33]

The training programme is designed to foster essential technical, cognitive, and ethical principles and communicative skills, enabling trainees to operate complex devices and manage patient care during high-risk surgical procedures. Simulation-based training is strongly encouraged, particularly for mastering emergency protocols and refining performance in high-stakes scenarios.[8,35,36] Upon completing the training, candidates must pass the ECCP examination, including practical, oral, and written assessments.[37]

Consensus Table 3. Clinical Training Requirements for Clinical Perfusionists

• The clinical part of training must be completed in specialized cardiac surgery departments with dedicated facilities, as specified by EACTS, and equipped with European guideline-based CPB equipment to ensure high-quality training.
• For examination, documentation of the minimum required number of supervised adult and paediatric clinical cases on CPB in accordance with the EBCP examination process must be shown.
• Clinical training cases must be structured and documented using a logbook based on EBCP requirements.
• Examinations must be conducted in accordance with the EBCP regulations and should include practical and oral components, with 2 examiners certified by the EBCP.
• European perfusionists should be certified by the EBCP, and the national authorities should mandate this certification as a minimum requirement for practice.

Abbreviations: CPB, Cardiopulmonary bypass; EACTS, European Association for Cardio-Thoracic Surgery; EBCP, European Board of Cardiovascular Perfusion.

6.3 Continuing education

Lifelong learning is an integral part of the clinical perfusionist's profession. Maintaining ECCP certification requires ongoing professional development to stay current with evolving technologies and best practices. The certification is valid for a period of 3 years. To retain it, clinical perfusionists must demonstrate a minimum level of clinical activity each year and participate in regular scientific or educational activities, which are reviewed during the triennial recertification process (40 clinical perfusion cases and 40 points per year in postgraduate education, as outlined in the EBCP requirements).[38]

Furthermore, perfusionists are expected to operate within a structured quality management system to support sustained excellence. Departments should implement standardized operating procedures and risk assessment protocols, reflecting the complexity of modern perfusion practice.[39] Additionally, regular team-based evaluations, including audits, peer reviews, and performance tracking, further enhance the delivery of high-quality care.[40] In tandem with these systems, institutions must establish transparent and effective mechanisms for reporting critical incidents to facilitate learning from errors and ensure continuous improvements in patient safety.

Consensus Table 4. Continuing Education Requirements of Clinical Perfusionists

• All clinical perfusionists must participate in the EBCP recertification process, demonstrating continued engagement in scientific activities and clinical practice, as well as regular participation in ongoing training and professional development.

Abbreviation: EBCP, European Board of Cardiovascular Perfusion.

7. COMPETENCES AND SKILLS

Clinical perfusionists should possess a comprehensive range of competencies that enable them to fulfil their highly specialized role across various procedures effectively. As critical healthcare team members, they are responsible for managing ECC, including CPB and organ perfusion, and ensuring adequate oxygenation and perfusion during surgical interventions. To perform safely and effectively, clinical perfusionists must demonstrate proficiency in a broad spectrum of clinical techniques, including the use of advanced support systems and relevant laboratory analyses. In line with the profession's ongoing evolution, the continuous expansion of expertise into areas such as echocardiography has become standard practice in many clinics and is crucial for the further development of perfusionists. In addition to practical and technical skills, perfusionists require an in-depth understanding of scientific data analysis and interpretation. They must be able to apply this knowledge to the situations they encounter in their daily work. The essential competencies required for this role can be broadly categorized into 3 domains: technical competencies, critical thinking abilities, and interpersonal skills.[13]

7.1 Technical competencies

Clinical perfusionists must demonstrate proficiency in the fundamental actions, assessments, and procedures indispensable to adult CPB and related circulatory support techniques. Additionally, all perfusionists should have a fundamental grasp of the medical management and clinical perfusion of neonates and children. These technical skills are essential to maintaining patient safety and optimizing clinical outcomes across both routine and high-risk interventions.[1,41-45]

Knowledge of anatomy and physiology. A profound understanding of human anatomy, particularly the cardiovascular and respiratory systems, kidneys, and liver, is essential for anticipating physiological responses and guiding intraoperative decision-making.

Understanding the pathophysiology of adult and congenital heart, vascular, kidney, and liver diseases. Perfusionists must comprehensively understand disease-specific pathophysiology to support safe and effective management during surgical or catheter-based procedures in both adult and paediatric populations.

Proficiency in equipment operation. Perfusionists must be capable of operating and managing complex ECC systems, including CPB, extracorporeal membrane oxygenation, intra-aortic balloon pumps, micro-axial flow pumps, ventricular assist devices, blood-salvage and transfusion devices, machine perfusion systems, and an artificial heart. Competency includes system set-up, priming, continuous intraoperative management, and troubleshooting across operating theatres, ICUs, and other critical care settings.

Expertise in biochemistry. Biochemistry plays a critical role in understanding physiological and metabolic processes that must be managed when operating extracorporeal circulation equipment, such as the HLM, during cardiac surgery.

Pharmacological expertise. A solid foundation in pharmacology is necessary to manage the administration of

anticoagulants, vasoactive agents, and other critical medications intraoperatively.

Blood management. Clinical perfusionists must be comprehensively trained in blood conservation techniques, haemostasis management (including the use of laboratory equipment), autotransfusion systems, haemofiltration, and the transfusion of blood components. This knowledge is crucial for maintaining haemostasis and preventing clotting disorders.

Medical engineering knowledge. Clinical familiarity with the maintenance and regulatory framework governing medical devices (eg, Medical Device Regulation 2017/745) is essential. Perfusionists should ensure proper documentation, compliance, and safe integration of equipment into patient care workflows.

Education and mentorship. Perfusionists frequently serve as educators and mentors, particularly in interdisciplinary environments. They may provide instruction on extracorporeal life support to ICU staff, students, and junior colleagues, contributing to institutional training programs.[46]

Data interpretation. Accurate interpretation of physiological and biochemical data, such as arterial blood gases, haemodynamics, and perfusion indices, is fundamental knowledge for clinical perfusionists to inform intraoperative decision-making.

Data sciences. Expertise in data science is becoming increasingly valuable for perfusionists. The field of perfusion has the potential to adopt data-driven and artificial intelligence tools to enhance clinical decision-making, optimize patient care, and advance research. Therefore, future perfusionists should have competencies in data science.

7.2 Critical thinking and problem-solving skills

In addition to technical proficiency, clinical perfusionists must demonstrate advanced non-technical competencies, including decision-making, communication, and operational management. These abilities are essential for delivering safe, responsive, and effective care in dynamic clinical environments. Structured training and certification pathways, such as the EBCP, play a vital role in standardizing these competencies across diverse healthcare systems. Several areas are critical in the context of ECC procedures.

Rapid decision-making. Perfusionists must be capable of evaluating changing clinical conditions in real time and initiating appropriate responses, particularly during emergency or unexpected events.

Analytical thinking. The ability to synthesize complex physiological, biochemical, and technical data is essential for ensuring safe and effective perfusion management throughout the perioperative period.

Troubleshooting and resilience. Clinical perfusionists must efficiently identify, diagnose, and resolve technical or procedural issues while maintaining composure and clinical focus under pressure.

7.3 Interpersonal qualities

Beyond technical and cognitive capabilities, clinical perfusionists are expected to exhibit a high level of professional conduct and interpersonal effectiveness. These attributes are central to collaboration within multidisciplinary surgical teams and the overall quality of patient care.

Situation awareness and judgement. Perfusionists must maintain a high level of environmental awareness in the operating theatre, enabling them to make timely and context-appropriate decisions.[47]

Task management and leadership. Effective task prioritization, workflow coordination, and team leadership are vital for ensuring smooth and safe procedural execution.[47]

Teamwork and communication. Strong communication skills are essential for safe collaboration with surgeons, anaesthesiologists, nurses, and technical staff, as well as for mitigating the risk of errors in high-stakes cardiac surgery environments.[44,47]

Attention to detail. Precision is essential in monitoring perfusion parameters, responding to clinical cues, and documenting procedural data.

Adaptability. Given the fast-paced and unpredictable nature of cardiac surgery, perfusionists must remain flexible and responsive to evolving intraoperative demands.

Compassion and empathy. A patient-centred approach that incorporates empathy and emotional intelligence fosters holistic care and ethical practice.

Commitment to lifelong learning. Ongoing engagement in professional development is crucial for staying current with advances in perfusion technologies, guidelines, and safety standards.

7.4 Facultative skills and competencies

In addition to core qualifications, clinical perfusionists may acquire a range of facultative skills (eg, optional but professionally valuable). These can be divided into technical ("hard") skills, which reflect specific practical competencies required for specialized tasks, and non-technical ("soft") skills, which reflect personality traits and interpersonal capacities that evolve throughout one's professional development. It should be noted that some of the skills presented here are already covered in the perfusionist degree programme. This programme includes content relating to paediatric and neonatal perfusion, vascular surgery, and oncology, in particular. The main objective of the facultative courses is to cover practical aspects and more in-depth content. The availability and application of these competencies vary across countries, depending on local regulations and healthcare systems. Acquisition of hard skills is typically supported through supplemental education, elective training programs, and institutional development initiatives (**Table 2**).

Soft skills refer to personality traits and behavioural attributes that are either inherently present to varying degrees or are

Table 2. Hard Facultative Skills Include Advanced Technical Competencies

Paediatric Perfusion	• Competency in congenital heart surgery perfusion techniques • Management of paediatric and ACHD cases • Maintenance of procedure volume to retain specialized skills
Rhythmology	• Advanced understanding of electrophysiological systems and their anatomical/physiological basis • Competence in implanting pacemakers and defibrillators, management, and follow-up
Interventional cardiovascular and radiology procedures	• Involvement in TAVI procedures • Competency in pre-procedural imaging and planning • Participation in hybrid procedures and angiographic support
Mechanical circulatory support	• In-depth knowledge of temporary and long-term MCS systems, including their technical and physiological implications • Understanding of VAD management and coordination
Organ transplants	• Support for organ harvesting and preservation • Exposure to tissue engineering practices
Organ perfusion	• Execution of ex vivo organ perfusion techniques • Involvement in normothermic regional perfusion and DCD settings
Oncology	• Hyperthermic intraperitoneal chemotherapy
Vascular operations	• Selective organ perfusion in aortic procedures • ECC in vascular surgery (eg, left heart bypass)
Surgical support	• Assistance with surgical procedures, including vein harvesting • Preparation and preservation of homografts
Hospital management	• Skills in the operational and financial management of perfusion units • Operating theatre logistics and coordination • Familiarity with quality assurance and administrative practices
Continuous education	• Organizing and documenting in-house and external training activities for staff • Conducting educational sessions within the clinic and in academic or external settings • Promoting continued professional development in line with EBCP recertification requirements
Scientific research and academic teaching	• Participation in university-level education • Engagement in clinical research, including data handling and interpretation • Contribution to preclinical experimental perfusion and laboratory research

Abbreviations: ACHD, adult congenital heart disease; DCD, donation after circulatory death; EBCP, European Board of Cardiovascular Perfusion; ECC, extracorporeal circulation; MCS, mechanical circulatory support; TAVI, transcatheter aortic valve implantation; VAD, ventricular assist device.

cultivated throughout a professional career. These traits play a fundamental role in shaping the identity and competence of clinical perfusionists. Although they are often less tangible than technical knowledge, soft skills are essential for effective functioning within multidisciplinary clinical environments and contribute significantly to overall professional performance. Key soft skills for clinical perfusionists include emotional intelligence and empathy in patient care, leadership and mentorship capacity, conflict resolution and teamwork dynamics, adaptability in high-pressure settings, effective communication across professional boundaries, and a sustained commitment to lifelong learning and knowledge dissemination. Together, these attributes enhance interpersonal effectiveness, support ethical and patient-centred care, and strengthen the collaborative fabric of surgical and critical care teams.

The successful execution of a clinical perfusionist's duties, particularly in high-stakes environments such as cardiac theatres, is predicated on core proficiencies and the acquisition and integration of these facultative competencies. These skills collectively enhance the quality and breadth of care, reinforce multidisciplinary collaboration, and support innovation within the field.[48]

As integral members of the perioperative and critical care team, clinical perfusionists draw upon a dynamic combination of technical excellence, critical reasoning, and interpersonal effectiveness to ensure optimal outcomes and uphold the highest patient safety standards.

Consensus Table 5. Competencies and Skills of Clinical Perfusionists

• The skills and competencies outlined in this consensus document should serve as the foundation for the profession of a clinical perfusionist.
• Clinical perfusionists must have specific training for any medical device or applications in their use in accordance with the European Medical Device Regulation (MDR 2017/745) and the national legal requirements.
• Further qualifications in other practising areas should be acquired through facultative courses.

8. EXPERTISE OF CLINICAL PERFUSIONISTS

The EBCP defines levels of professional expertise for clinical perfusionists based on a combination of formal theoretical education and accumulated clinical experience. For practising perfusionists, the extent of practical activity is a key determinant of their ability to work autonomously, apply problem-solving skills, manage increasing levels of responsibility, and demonstrate leadership within clinical settings. The following proposed framework outlines general expectations associated with each stage of expertise, recognizing that individual abilities may vary

significantly. To be recognized at the next level of expertise, the perfusionist must have primarily worked in a perfusion department.

8.1 Junior Clinical Perfusionist (*<500 perfusions and/or 0-3 years of experience*)

After completing approximately 100 independently performed procedures under supervision and passing a practical examination, the junior clinical perfusionist is considered competent to carry out standard procedures safely. At this stage, perfusionists can perform assigned duties in accordance with recognized professional standards. In principle, they can recognize clinical signs, initiate safe responses, and devise appropriate management strategies. However, they must also be able to assess whether they can solve the problem themselves or if they need to consult with more experienced colleagues.

8.2 Mid-level Perfusionist (*500-1200 perfusions and/or 3-8 years of experience*)

After approximately 500 independently performed procedures, the clinical perfusionist is expected to have encountered the most common intraoperative events and complications. They can recognize clinical signs, initiate safe responses, and formulate appropriate management strategies. When cases exceed their expertise, they are expected to seek timely support from senior colleagues.

At this level, perfusionists often begin training in more advanced procedures (eg, paediatric perfusion procedures) and may assume mentoring roles. They are encouraged to contribute to clinical education through lectures, training sessions, and engagement with current scientific developments. Participation in research activities and active involvement in national or international scientific meetings are strongly recommended.

8.3 Senior Clinical Perfusionist (*>1200 perfusions and/or >8 years of experience*)

Senior clinical perfusionists possess the expertise to manage all types of procedures and intraoperative complications with high autonomy and confidence. They are well-positioned to mentor junior colleagues, provide theoretical instruction, and contribute their knowledge to institutional training and guideline development.

8.4 Chief Perfusionist

A chief perfusionist is an experienced senior perfusionist responsible for departmental leadership and strategic planning. Beyond clinical expertise, the chief perfusionist must demonstrate advanced competencies in personnel management, resource allocation, interdisciplinary coordination, and compliance with healthcare regulations.

Chief perfusionists ensure their department's adherence to quality standards, oversee internal training, and manage EBCP certification and recertification processes. They play a pivotal role in organizing continuing education, liaising with suppliers, and supporting institutional procurement procedures for perfusion-related equipment and consumables.

Consensus Table 6. The Level of Expertise of Clinical Perfusionists

• The level of expertise of clinical perfusionists is reflected in different experience levels: "Junior", "mid-level," "senior", and "chief" clinical perfusionists. This classification should determine the areas of clinical activity and other related tasks.
• The chief perfusionist must possess senior-level experience along with additional training in personnel and healthcare management.

9. RESPONSIBILITIES AND PROFESSIONAL LEGAL ASPECTS

Clinical perfusionists in Europe operate primarily under a delegation model rather than a substitution model. This distinction is critical to understanding their legal and professional role within the interdisciplinary medical team. Delegation typically originates from physicians, most often cardiac surgeons or anaesthesiologists, and is structured to ensure both patient safety and procedural efficacy. Delegation in clinical perfusion practice is typically divided into 2 key categories: general delegation and specific delegation.

9.1 General Delegation

General delegation encompasses routine responsibilities that fall within the clinical perfusionist's core scope of practice. These activities may be performed independently in a structured and predefined agreement between the physician and the perfusionist. Clinical perfusionists are authorized within this framework to manage ECC systems, including the HLM, without direct supervision.[4] Clinical perfusionists are responsible for (1) preparing and testing perfusion equipment before its use; (2) operating and monitoring ECC during surgical procedures; (3) managing perfusate composition and performing blood gas analysis; (4) making intraoperative adjustments to the ECC circuit based on surgical requirements; and (5) selecting and configuring appropriate equipment, including arterial pumps, suction systems, venting circuits, and venous reservoirs. These actions are guided by national and institutional protocols, including standard operating procedures, and rely on the perfusionist's professional training and clinical judgement. The general delegation model reflects trust in the perfusionist's technical competence and ability to uphold safety standards independently within their scope of practice.

9.2 Specific Delegation

Specific delegation pertains to patient-specific interventions that require direct medical oversight or consultation. These responsibilities fall outside routine tasks and typically involve (1) administration of medications, anticoagulants, or blood products; (2) adjustment of perfusion parameters in complex or emergency situations; (3) interpretation of physiological abnormalities requiring diagnostic clarification; and (4) implementation of novel or non-standard procedures. In such cases, the perfusionist acts under the direct supervision of a physician, according to

the clinical context and applicable legal framework. Although perfusionists are responsible for executing delegated tasks, they do not practice medicine autonomously. Their contributions are instead embedded within a collaborative model that ensures safe and effective patient care through interdisciplinary coordination.[4]

In summary, whereas clinical perfusionists play a pivotal role in cardiac surgery and other ECC procedures, their function is not to substitute for a physician but to act within a clearly defined framework of medical delegation. They apply their specialized expertise to support the medical team within this structure, contributing to safe and effective patient care. This delegated role ensures that complex procedures can be performed efficiently and safely while preserving clear responsibility and medical oversight boundaries. Notably, general delegation permits clinical perfusionists to work independently within a well-defined scope of action. However, any deviation from established protocols or engagement in patient-specific decision-making necessitates direct consultation with the responsible physician, falling under the category of specific delegation.[4]

Consensus Table 7. Responsibilities and Professional Legal Aspects

• As a healthcare professional, the clinical perfusionist must act as an integral part of the medical team.
• The clinical perfusionist independently conducts CPB within SOPs, in close collaboration with the cardiac surgeon and anaesthesiologist, tailored to the patient's unique needs.

Abbreviations: CPB, cardiopulmonary bypass; SOPs, standard operating procedures.

10. QUALITY ASSURANCE AND IMPROVEMENTS

Maintaining high safety standards, consistency, and clinical effectiveness is essential in the context of ECC. Quality assurance and continuous quality improvement processes are fundamental to modern perfusion practice, supporting optimal patient outcomes and fostering regional and broader professional accountability.

10.1 Quality Improvement

Quality improvement is a fundamental aspect of clinical perfusion, given the critical nature of ECC procedures, such as CPB. Given the high-risk environment in which clinical perfusionists operate, minor errors or equipment malfunctions can have serious, life-threatening consequences. Therefore, continuous quality improvement initiatives are essential to ensure the highest patient safety and clinical care standards. The implementation of structured quality improvement processes supports the identification and mitigation of risks, the standardization of procedures, and the optimization of perfusion performance. Adherence to evidence-based guidelines and established best practices enables clinical perfusionists to consistently deliver high-quality outcomes and strengthen patient trust in the healthcare system. Moreover, continuous quality improvement efforts play a crucial role in the ongoing professional development of clinical perfusionists by ensuring alignment with the latest innovations and evidence. This constant engagement is vital for maintaining certification and competencies, as well as fostering a culture of excellence and accountability.

Across Europe, established systems for quality improvement and incident reporting in perfusion are already in place and play a pivotal role in enhancing safety and clinical outcomes during ECC procedures, including CPB.[49-51] The integration of evidence-based guidelines, institutional policies, and professional accreditation frameworks supports quality assurance and continuous improvement in clinical perfusion practice across Europe. International guidelines, primarily developed by the EBCP, the EACTS, and the EACTAIC, form the foundation for setting standards in training and clinical performance. These guidelines promote procedural consistency, risk mitigation, and patient safety during ECC. In parallel, the maintenance of certification through structured continuing professional development is essential for ensuring clinical competence. European-certified perfusionists are required to participate in periodic educational activities that include simulation-based training, skills workshops, and multidisciplinary seminars, all of which contribute to improved preparedness in managing critical incidents and advancing clinical performance.

Furthermore, performance monitoring is increasingly embedded in daily practice, with many European centres implementing data-driven quality improvement programmes. These programmes involve the systematic audit of perfusion procedures, a review of equipment functionality, and an analysis of patient outcomes. Benchmarking against national or institutional databases facilitates the early identification of procedural deficiencies and supports the implementation of corrective measures. The main areas of the present quality improvement initiatives include the reduction of adverse events such as air embolism and equipment failure, the application of patient-tailored perfusion techniques (eg, individualized flow rates, oxygen delivery, and anticoagulation strategies), and the structured implementation of guideline-based approaches for specific populations, including neonates and patients undergoing minimally invasive procedures. These strategies collectively reinforce the clinical, technical, and ethical standards of European perfusion practice.

Consensus Table 8. Quality Assurance and Improvements

• Clinical perfusionists should collect electronic automated data regarding the conduct of perfusion via a clinical registry or database and use such data to actively participate in institutional and departmental quality assurance and improvement.
• The development of a European Perfusion Registry could serve as a foundational tool for standardized performance assessment, benchmarking, and continuous quality improvement across institutions.

10.2 Incident Reporting in Perfusion

Incident reporting is a critical component of safety assurance in clinical perfusion, aimed at identifying, documenting, and analysing adverse events and near-miss situations during ECC. The primary objective of such systems is not to accuse anyone of malpractice but to foster a transparent culture of continuous improvement and

shared learning within perfusion practice. Various reporting frameworks are employed at institutional, regional, and national levels around the world. Although some countries have developed dedicated national registries for perfusion-related incidents, others rely on hospital-based reporting systems that are integrated within broader healthcare quality management platforms. Different countries have different reporting frameworks for medical device and perfusion incidents. For example, the United States uses a passive Food and Drug Administration system, the MAUDE (Manufacturer and User Facility Device Experience) database, while Australia and New Zealand emphasize confidential learning and resilience by using an online database called the Perfusion Improvement Reporting System (PIRS-2), which is an incident and near-miss reporting tool. In Europe, France, for example, mandates a comprehensive online reporting tool for medical device failure in accordance with Regulation (EU) 2017/745 and French law,[52] overseen by its national safety agency.[53,54]

These systems support the systematic collection of data related to equipment failures, protocol deviations, and clinical complications, providing the basis for comprehensive root-cause analyses and targeted interventions.[55]

Several quality initiatives have emerged from these efforts.[56,57] The implementation of perfusion-specific registries facilitates the aggregation of multi-centre data and comparative analysis, enabling evidence-based refinements in clinical protocols. The use of structured safety checklists, particularly pre-bypass checklists, has become widespread and is associated with measurable improvements in procedural safety. Moreover, the integration of advanced technologies, including real-time monitoring systems and automated incident detection software, enhances the early recognition of deviations and streamlines the reporting process.

The EBCP advocates for harmonized incident reporting practices and encourages the development of collaborative frameworks that align with international quality improvement efforts. Cross-institutional data sharing enables benchmarking and supports the development of targeted training modules based on real-world case scenarios.[58] The current European guidelines on extracorporeal circulation include recommendations for recording systematic analyses of errors and events, as well as for using perioperative checklists. These are given a Class I and a Level C recommendation. The same level of recommendation is given for maintaining a national reporting system for adverse events.[8]

Incident reporting systems have contributed significantly to advancements in perfusion safety. Improvements in equipment design, standard operating procedures, and contingency planning strategies have been achieved through the analysis of reported data. In addition, insights from incident analyses have been incorporated into training curricula, ensuring that clinical perfusionists are equipped to manage rare but high-risk situations.

In summary, incident reporting in perfusion represents a cornerstone of quality assurance and professional accountability. Its effective implementation supports the ongoing development of safer, more reliable perfusion practices and reinforces the commitment of the perfusion community to patient-centred care and procedural excellence.[8]

11. FUTURE DIRECTIONS AND GAPS IN KNOWLEDGE

Clinical perfusion is currently undergoing a notable transition, characterized by technological innovation, changing clinical demands, and evolving expectations regarding professional roles. In this context, several trends will likely shape the future of clinical perfusion across Europe. One of the most significant developments is the gradual expansion of the perfusionist's role beyond the conventional confines of the operating theatre. Clinical perfusionists are increasingly employed in diverse clinical environments, including ICUs and emergency departments, where their expertise in ECC technologies contributes to the management of critically ill patients.[26] This broader clinical integration reflects the growing relevance of perfusion science in settings beyond traditional cardiac operations.

Simultaneously, ongoing advances in cardiovascular therapy, organ preservation, and mechanical circulatory support are redefining the scope of perfusion practice. Innovations in organ perfusion technologies and the evolution of treatment strategies for cardiac disease are expanding the clinical indications for ECC support.[59] As a result, perfusionists are required to acquire a wider range of technical skills and clinical knowledge to remain effective in increasingly complex care pathways.

The importance of simulation-based training is also expected to grow. Although its current utilization remains limited among practising perfusionists, simulation is a promising tool for developing and refining technical proficiency and decision-making under pressure. This is particularly relevant for high-acuity scenarios that cannot be routinely practised in clinical settings.[60]

At the systemic level, workforce planning will be crucial in addressing anticipated increases in demand for cardiovascular procedures. Without corresponding expansion in educational capacity, many countries may face a shortfall of qualified perfusionists.[24] Therefore, national and joint European policies must aim to reinforce and expand training programmes to ensure long-term sustainability.

Finally, harmonization and accreditation of academic training remain critical challenges in Europe. The current diversity of national education models hampers cross-border professional mobility and creates disparities in training quality. Establishing unified standards and strengthening the role of accreditation bodies such as the EBCP will be crucial to ensuring that clinical perfusionists across Europe are adequately prepared to meet future demands.[13] In addition, it has been strongly advocated that national and European authorities formally recognize the clinical perfusionist as a regulated healthcare professional. This recognition should be grounded in a harmonized framework of academic education, supervised clinical training, certification, and lifelong learning.

Consensus Table 9. Professional Recognition

- The professional societies contributing to this consensus paper strongly recommend that European and national policymakers formally recognize clinical perfusion as a regulated healthcare profession in order to ensure optimal patient care in clinical perfusion.

11.1 Educational, Professional, and Regulatory Priorities for the Development of Perfusion in Europe

Several targeted steps have been identified to support the continued advancement of the perfusionist profession in Europe.

Figure 2.. Educational, Professional, and Regulatory Actions to Advance the Perfusionist Profession in Europe. EBCP indicates the European Board of Cardiovascular Perfusion. ECLS indicates extracorporeal life support.

These measures are intended to guide key stakeholders, including professional societies, educational institutions, and regulatory bodies, in strengthening the role of clinical perfusionists. In parallel, perfusionists must be adequately equipped to meet the evolving demands of European healthcare systems and contribute meaningfully to multidisciplinary patient care (**Figure 2**).

12. CONCLUSIONS

The profession of clinical perfusionists is evolving in response to substantial shifts in healthcare delivery, medical technology, and professional expectations. Across Europe and beyond, recognition is growing that excellence in perfusion practice must be underpinned by a formalized, academically grounded education, robust clinical training, and a clear framework of professional competencies. Therefore, harmonizing educational pathways and aligning national standards remain key priorities for the sustainability and quality of the profession. Although many countries have made significant progress, the current patchwork of training models and recognition mechanisms continues to limit professional mobility and dilute the consistency of care. Bridging these gaps requires coordinated action among academic institutions, healthcare providers, and professional societies.

Beyond education, the evolving scope of clinical perfusion practice underscores the importance of equipping professionals with a range of technical and non-technical skills. From operating theatres to ICUs and emerging ECC applications, perfusionists must demonstrate clinical agility, sound judgement, and interdisciplinary collaboration.

As a highly technological field at the intersection of medicine and technology, clinical perfusion is subject to constant further development. Perfusionists play a pivotal role in researching and developing new, innovative, highly biocompatible systems and medical operation software, as well as incorporating these innovations into everyday clinical practice. This requires qualifications in both basic and clinical research, as well as recognition of perfusion as a scientific discipline.

Simulation training, structured continuing education, and modern quality assurance systems are central to preparing the workforce for these expanding demands. Moreover, with cardiovascular disease remaining a leading global burden, the demand

for qualified perfusionists is set to rise. Without strategic investment in training capacity and long-term workforce planning, healthcare systems risk facing critical shortages.

This consensus statement outlines a clear and unified vision for the qualifications and competencies required of European clinical perfusionists. By embracing a shared framework for education, certification, and professional development, the perfusion community can ensure the delivery of safe, effective, and future-ready care. The continued evolution of the profession must be matched by formal recognition of the profession and a commitment to excellence driven by expertise, supported by policy, and sustained through collaboration across national borders.

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DATA AVAILABILITY STATEMENT

No new data were generated or analysed in support of this research.

CONFLICTS OF INTEREST STATEMENT

Milan Milojevic reports the role of Guidelines Program Director at EACTS. Gudrun Kunst reports the role of Scientific Chair of EACTAIC. Gudrun Kunst is supported by an NIHR Senior Clinical and Practitioner Research Award (NIHR306274). The other authors report no COIs related to the present expert consensus document.

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13. SUPPLEMENTARY MATERIAL

Supplementary data are available at the *European Journal of Cardio-Thoracic Surgery* online, which includes sections on 1. Perfusion in different countries 2025, 2. The syllabus in perfusion sciences, and 3. Admission of an experienced perfusionist to the European Board of Cardiovascular Perfusion.

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