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The value of the modern embryologist to a successful IVF system: revisiting an age-old question

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Abstract

Background: The embryology laboratory remains one of the primary factors influencing the overall performance of the IVF clinic. Clinical embryology, however, has undergone remarkable advancements over the last decade. These developments in both practice and education have been driven together by science and technology.

Main body: The changes in clinical embryology practice have created a significant challenge for both the profession and the embryologist. New competencies for embryologists have subsequently emerged to provide and manage high-quality services for their patients and clinics. Embryologists' efficacy behind the scenes reflects positively on the success of the fertility clinic. This framework will serve as the flagship document to shed light on the often-overlooked value of the embryologist as an intellectual and intangible asset for the clinic.

Conclusion: To fully leverage a modern embryologist's skill set, significant investment is required from the IVF clinics' leadership, which is associated with a substantial return on the IVF clinic's success. From their side, embryologists should be up to date on further developments and innovations. On the other hand, mentors need to mend the curriculum to allow for better training of high-caliber embryologists.

Keywords: Embryologist, Clinical embryology, Professionalism, Value, Quality

Background

Clinical embryology is composed of two elements: science and art. The art component is depicted in practical skills and laboratory competencies. The scientific aspect includes embryologists' knowledge fund, critical thinking, problem-solving, and analytical skills. The evolution of clinical embryology over the past 20 years has been fueled by scientific and technological developments made possible by the surge of infertility cases seeking treatment. For instance, the development of embryo culture systems led to a significant revolution in in vitro high-quality blastocyst development using new culture media formulations and new generations of in vitro fertilization (IVF)-designed incubators [1]. At a faster pace, development in gene technology had a substantial effect on embryo testing art [2]. With further advancements, enhanced technological performance entailed the integration of biological, computer, and information sciences. This sophistication, termed artificial intelligence, will dramatically affect the embryologist's role in the future [3]. Under the influence of these factors, clinical embryology is likely to mature continuously. The technology-driven development changed some standard practices such as embryo annotation and embryo biopsy. With these changes, embryologists' basic skills had to be refined to make best use of this emerging technology and automation.

In addition to the technological advancements and innovation, an immense increase in knowledge and information led to another challenge in clinical embryology, which is the emergence of super branches such as

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epigenetics, regenerative medicine, stem cells, bioengineering, machine, and deep learning. This progress was inevitable in academic curricula. Nevertheless, the privileges of technological development and innovations are often restricted to wealthier countries. Similarly, access to emerging biology fields is limited to the individual's interest or academic need. Unfortunately, this may lead to disparities in clinical embryology practice.

Embryologists will need to adapt by acquiring new skills and competencies to support these changes. To meet these challenges, the authors, on behalf of the Middle East Fertility Society Embryology Specialty Interest Group, developed this flagship document for IVF clinic leadership and embryologists to shed light on the often-overlooked value of the embryologist as an intellectual and intangible asset.

Main text

The embryologist

Clinical embryologists' performance reflects more than technical skills alone. The ability to execute gametes/embryos manipulation efficiently, meticulously, and safely is borne from experience, cognitive abilities, motor skills, hand-eye coordination, and dexterity. The practice of clinical embryology depends not only on cognitive and technical skills but also on an operator's ability to manage time and stress and integrate into a multidisciplinary care team.

The embryologist's role has evolved partly due to specialization, educational qualifications, scientific development, certification in clinical embryology, and continuous professional development (CPD) credit requirement. The modern embryologist's duties and responsibilities have substantially increased to include the formulation of policies and protocols, identification of critical factors to maximize outcomes, and the ability of prompt problem-solving and decision-making, where a solid scientific background is essential. Consequently, various medical board associations have implemented a career ladder system based on a combination of formal education and experience [4, 5]. This tool is vital for staff motivation and productivity, and for the clinics' recruitment potential.

Besides technical competence, an embryologist's traits could be intertwined to various domains: interpersonal and communication skills, high moral performance, strong work ethics, and passion for learning new things. High moral performance entails conscientiousness, dedication, and acceptance of responsibilities for actions. Work ethics include trustworthiness, integrity, and proactivity. Furthermore, part of strong work ethics includes teaching and training the new generation of embryologists.

With these general characteristics, the "good embryologist" should be intelligent, perseverant, meticulous, calm, conscientious, creative, and composed under stress. He/she should also be a good communicator, mentor, researcher, and team member. Beyond these, he/she should be committed to excellence in practice and feel responsible for continuous self-development. These traits are best accompanied by professional responsibilities and values, such as empathy, honesty, integrity, dedication and devotion, nondiscrimination, compassion, and ethics. In Fig. 1, we illustrate the seven key roles of the successful embryologist.

Value of embryologists' roles and quality of their work

Evaluating the quality of embryologists' work and the importance of their role is a complex task. Numerous measures can be adopted as quality indicators for assessing embryologists' procedural technical skills. New competencies for the modern embryologist are thriving, which also reflect positively in the fertility clinic's success. The core competencies of embryologists associated with key outcome areas are summarized in Table 1.

Technical expertise

The embryologist's career qualifications coupled with laboratory and clinical data are a powerful resource to identify differences in embryologists' attributes, such as logbooks of experience and training. However, the extent to which experience influences embryologists' performance remains poorly studied. Tiegs and Scott retrospectively evaluated around 14,000 intracytoplasmic sperm injection (ICSI) procedures performed by 20 embryologists, whereby at least two embryologists carried out a single cohort of oocytes. This paired analysis pointed out an association between increased ICSI operator experience, higher fertilization rates, higher blastocyst development, and sustained implantation rates. Laboratory and clinical outcomes increased with the embryologist's experience and technique improvement, eventually reaching a steady state after a minimum of 1000 ICSI procedures [6]. Similarly, a previous study highlighted the ICSI operator's role as a crucial predictor for fertilization rate [7].

A positive linear association has been previously demonstrated between the extent of an embryologist's skills with ICSI and enhanced oocyte survival and successful fertilization [18, 19]. This finding might be attributed in part to the speed acquired with training and experience in performing necessary procedures. In this regard, Maggiulli and colleagues recently studied the mean procedural timing for performing denudation and ICSI recorded through an electronic witnessing system between fourteen ESHRE (European Society for Human Reproduction and Embryology) certified embryologists

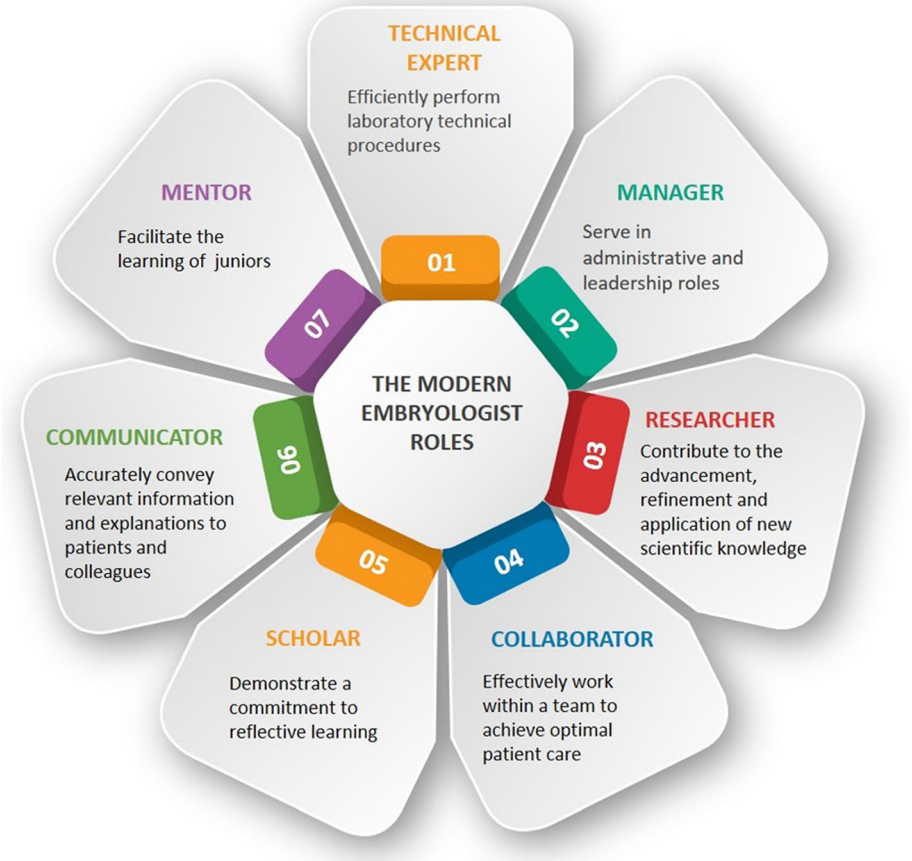

Fig. 1 Diagram of the seven key roles of the successful embryologist

of 1 to 14 years of clinical experience. They noticed that the procedural timings were shorter in highly experienced operators [8]. Therefore, fast-paced operators impact overall laboratory efficiency and productivity. Nevertheless, such variability in the operator's experience and procedural timings was not reflected in embryological and clinical data, such as blastulation and cumulative delivery rates [8]. The ICSI operator's role can also be attributed to the subjective selection of the "ideal" sperm and the injection technique [20].

It is becoming increasingly clear that embryologists' training affects laboratory and clinical outcomes. In more complex procedures than ICSI such as embryo biopsy, embryologists' proper training, and expertise are essential for optimal results. Capalbo et al. reported highly consistent and reproducible genetic laboratory and clinical outcomes across seven embryologists from different laboratories within a single organization that received identical training and used similar equipment for trophectoderm biopsy [9]. Vitrification is also a high operator-dependent technique requiring specific training and diligence to procedural details to reach optimal survival rates [10]. Many hands-on training programs have been tailored focusing on tips and tricks for embryo biopsy and vitrification techniques. Yet, it is noteworthy that the available evidence is mainly derived from observational studies, which calls for multicenter well-designed studies encompassing different laboratory conditions and protocols. The "practice makes perfect" concept considers the embryologists' case volume as the primary determinant of expertise to maintain proficiency, avoid skill degradation, and optimize outcomes. Clinical embryology is a dynamic practice. In their early years of practice, embryologists are more likely to perform the basic IVF/ICSI procedures. Senior embryologists additionally perform the most challenging cases and the more complex procedures such as embryo biopsy and vitrification.

Table 1 The core competencies of embryologists associated with key outcome areas

Competency	Key outcome area	References
Technical expertise *(acquired through training or high procedural volume)*	▪ Higher fertilization rates and lower degeneration rates post-ICSI	[6, 7]
	▪ High usable blastocysts and higher sustained implantation	[6]
	▪ Shorter procedural timings affecting the overall laboratory efficiency and productivity	[8]
	▪ Consistent and reproducible laboratory and clinical outcomes after embryo biopsy	[9]
	▪ Higher survival rates following vitrification	[10]
Scientific expertise	▪ Licensing and certification, based on academic qualifications, operative logbooks experience, knowledge examination, and continuing education programs, is a requirement in many countries and contribute to embryologists' prestige	[11, 12]
Management	▪ Problem-solving and troubleshooting processes to maintain the highest and consistently reliable outcomes	[13, 14]
	▪ Security of continuity of care through prophylactic laboratory management in case of emergencies	[4]
Decision-making	▪ Informed and timely decisions regarding embryo morphological assessment for transfer or vitrification to optimize patients' outcomes	[15]
Collaboration and teamwork	▪ A team approach to troubleshooting when sub-optimal outcomes are encountered	
	▪ Effective teamwork reduces inter-professional conflicts and maximizes outcomes	
Communication	▪ Establishing rapport, empathy, trust, and delivering information for optimal patient outcomes and retention Communication among the clinic's teams for timely problem-solving and maintaining a comfortable work-place environment	[16, 17]
Scholarship and teaching	▪ Sponsored trials generate income and add prestige to the embryologist and the clinic	
	▪ Increase staff satisfaction	
Professionalism	▪ Work within the standards and maintenance of standards of ethics, probity, and confidentiality	
	▪ Effective teamwork based on respectful and culturally competent behaviors	
	▪ Work ethics includes teaching and training by transferring the knowledge and experience to juniors	

Embryologists' exclusive technical work within standardized processes will finally lead to a plateauing of quality. Scientific reasoning and personal skills will then further improve quality.

Non-technical skills

Besides technical expertise, embryologists' success depends on their behavioral performance and interpersonal strengths such as decision-making, stress management, leadership, and team working. These competencies are developed in an informal manner rather than being addressed explicitly in training. Problem-solving and planning are essential skills required for daily laboratory activities to maintain the highest and consistently reliable outcomes. For instance, embryologists monitor the laboratory performance and troubleshooting by analyzing processes [13, 14] and through team discussions. Embryologists are also involved in the prophylactic laboratory planning for emergencies such as natural disasters or pandemics to ensure the continuity of patient care [4]. Embryologists are challenged with clinical decision-making on a daily basis. Effective decision-making is beneficial to promote positive patient outcomes. Morphological assessment and embryo selection training are decisive to increase agreement between embryologists on the clinical decision for transfer or vitrification of embryos [15]. However, inter-observer and intra-observer agreements for embryo selection are sub-optimal even among experienced embryologists [15, 21, 22].

The IVF laboratory work is highly demanding and often stressful, causing burnout and depression in embryologists that may undermine the quality of care and contribute to errors [23, 24]. Continuity of care implies that embryologists should be flexible and full-time available to provide an adequate response for the frequent laboratory activities and the urgent demands.

Scientific expertise

Embryologists' knowledge is assessed through board certification and licensure. Knowledge is typically measured with traditional assessments such as written exams. A minimum of academic qualifications, operative logbook experience are required to be eligible for examination [11, 12]. Embryologists maintain their certification through ongoing education. Licensing and certification of embryologists in supervisory and directorial positions are a requirement for IVF clinics in many countries [11]. To date, however, it is less clear how to measure and regulate embryologists' technical abilities.

Scholarship and mentorship

Research is the cornerstone of evidence-based clinical practice. There is a need for greater participation in research by embryologists to study laboratory observations objectively and scientifically. Clinical research is

considered a key to advancing clinical embryology knowledge. It provides embryologists with an opportunity to offer patients the latest cutting-edge practices. Participation in research, for example, in sponsored trials, would generate income and add prestige to the clinic and the embryologist's practice.

Another potential benefit to the clinic is in-house mentoring and training. One of the embryologist's vibrant roles is his commitment to learning, advancement, refinement, and application of new scientific knowledge. Embryologists may be involved in mentoring trainees through guided visits or hands-on training. Motivation to teach can be classified into two camps: (i)"extrinsic motivations" such as financial compensation, teaching awards, or academic appointment and (ii)"intrinsic motivations" such as enjoyment in observing teaching outcomes, a sense of duty, or a self-reflection on own skills. Training programs generate income for the clinic and boost staff satisfaction.

Communication

Currently, most IVF clinics enable patient-embryologist communication to establish rapport, empathy, and trust. While poor communication with patients can lead to undesired outcomes such as increased stress and mistrust, effective communication is critical to sustaining optimal patient outcomes and retention [16]. Embryologists are gradually integrating this new role as communicators and counselors into practice [17]. Cooperation and communication among the laboratory and the medical teams are also necessary for timely problem-solving and maintaining a comfortable workplace environment.

Implementing the core competencies of the modern embryologist

This article offers a starting point for defining attributes of a good embryologist as a basis for developing a competency-based curriculum for educators and professional medical societies, encompassing knowledge, skills, and attitudes to improve patient care and quality. Newly designed curricula content for academia and continuing professional development activities should include learning and teaching methods, assessment, and evaluation of embryologists' competencies.

Within this framework, we propose a roadmap for the acquisition of the good embryologist's competencies:

- Create online self-assessment programs that enable embryologists to monitor their knowledge.
- Integrate digital technology into education through blogs, podcasts, and influential videos from expert speakers such as TED talks.
- Design a trusted education management online platform to report training logbooks and include a knowledge assessment passport.
- Establish an international board for embryologists to conduct online-proctored certification examinations.
- Develop structured technical skills assessment tools as part of the in-training examination and skills testing.
- Integrate non-technical behavioral skills coaching for cognitive (e.g., decision-making), interpersonal (e.g., teamwork, leadership), and resilience skills into educational activities.
- Use of Journal club activities to critically appraise and debate published articles targeting IVF laboratory issues.
- Establish clinical embryology research networks for initiating fruitful collaborations in research projects and surveys.
- Develop mentor match programs that give mentees exclusive access to a robust network of international and local mentors eager to share their wisdom and advice about their professional lives.
- Develop role modeling workshops and toolkits for seniors to engage them in teaching and training junior embryologists.

Future directions

Most embryology groups have focused on delivering educational content. The Middle East Fertility Society (MEFS) Embryology Specialty Interest Group supported the same mission for ongoing education. However, we aim to change strategy towards the empowerment of embryologists in conjunction with education. How do we differentiate ourselves? Blue Ocean Strategy by Kim and Mauborgne is one of the most iconic strategy books on creating an uncontested marketplace [25]. Blue Ocean Strategy outlines how a successful business aims to differentiate itself from the market space by focusing on value innovation. Inspired by this strategy, our efforts will focus on providing brand development and recognition for embryologists. The Blue Ocean Strategy prescription for value and branding clinical embryologists will be our secret sauce. The first step is this flagship document for IVF clinics' leadership and embryologists to shed light on the embryologist's often-overlooked value as an intellectual and intangible asset for the clinic. In the next step, we aim to develop a collaborative platform that includes knowledge resources, non-technical skills development programs, branding portfolios, and valuation resources, thereby allowing a comprehensive growth of embryologists.

Conclusions

IVF accounts for a substantial proportion of women's healthcare services delivered worldwide. Embryologists' attributes and competencies greatly impact IVF laboratory performance and clinical quality. Identifying all aspects of embryologists' performance including knowledge,

technical, and non-technical skills, can ensure that all providers enjoy productive, satisfied, high-caliber, and robust practices. IVF clinic leaders need to properly recognize the pivotal role of embryologists in an IVF clinic's success. On the other hand, mentors need to design future curricula for better training of high-caliber embryologists.

Abbreviations

CPD: Continuous professional development; ESHRE: European Society for Human Reproduction and Embryology; ICSI: Intracytoplasmic sperm injection; IVF: In vitro fertilization; MEFS: Middle East Fertility Society

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Competing interests

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