

# Cardiac surgery: the infinite quest. Part III - Pediatric cardiac surgery: a discipline on its own

## *Cirurgia cardíaca: a busca infinita. Parte III - Cirurgia cardíaca pediátrica: uma disciplina por si só*

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*O último dos três tópicos deste ensaio enfatiza as particularidades da cirurgia cardíaca pediátrica. Espero que a série de textos possa ter levado à reflexão sobre como lidamos com vários aspectos ligados à nossa especialidade e sirva de impulso para adoção de novas medidas, a fim de elevar o nível de excelência da cirurgia cardiovascular, proporcionando o bem-estar do paciente, que é nosso objetivo maior.*

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**Ultramini-abstract:** *Although there are common grounds with adult cardiac surgery, it is important to understand the differences in the business plan, paths, manpower, mindset, training, and infrastructure that are essential in those institutions where pediatric cardiac surgery can and should be performed. Time to start thinking, it is not what we can do, but should we do it?*

### **Pediatric cardiac surgery**

Pediatric cardiac surgery has been available for many years in several developing countries, thanks to the creative adaptation of individuals who were able to stretch the limits of their abilities in spite of the restricted resources that forced them to work harder but not allowing them to work smarter. In this context, economic constraint is a constant problem forcing those involved to focus on short-term solutions for tomorrow's needs. It was sometimes tougher to deal with the multiple stumbling blocks than with the patient condition. After all, we were trying to keep our feet on the ground and our heads in the clouds.

Leadership, patience, reflection, self-discipline, perseverance, dedication, the capacity to adapt, and the creativity that comes with having to work under adverse circumstances were the keys to success but do not necessarily ensure sustainability [1]. Still, worldwide we have islands of

excellence in an ocean where millions of people living outside North America, Australia, and Europe have limited or no access to pediatric cardiac surgery.

**Making the impossible possible:** The most conspicuous advantage of the human mind is its remarkable ability to simplify complex tasks, but due to the limitations of simplification it is both a strength and a weakness. The escalating costs and the lack of money required to simplify the surgical process led to implementing an ingenious multi-principle *adaptive work* —the KISS (**Keep It Simple and Safe**) approach — in order to help more patients with the available funds, equipment and manpower. However, the danger of oversimplification of the complex process of policy formulation is substantial. Solutions often reside not in the executive suite but in the collective intelligence of people at all levels, who need to use each other's resources and learn their way to those solutions [1].

The road to successful development and change in a program depends on numerous variables that include government and hospital administration support, consistent medical staff leadership, and a medical staff that is receptive and committed to protocolizing peri-operative diagnosis and management algorithms, data acquisition, and implementation of a quality assurance program.

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Abbreviations, acronyms & symbols	
<b>CPB</b>	Cardiopulmonary by-pass
<b>HLHS</b>	Hypoplastic left heart syndrome
<b>KISS</b>	Keep It Simple and Safe
<b>PCCC</b>	Pediatric Cardiac Care Consortium
<b>RACHS</b>	Risk Adjustment for Congenital Heart Disease
<b>TGA</b>	Transposition of the great arteries

**International/National Cooperation:** Because the world faces many formidable problems, we cannot expect to solve the mal-distribution and poor access to cardiac surgery through the regular channels for international aid. Currently, there are numerous groups around the world involved with structured international projects with the support of non-governmental organizations together with other members of civil society, but without coordination among them. In humanitarian medicine, there is room for cooperation rather than competition, because the people in need outnumber those able to provide assistance. In those countries where mal-distribution of access is the main problem, the existing centers of excellence can contribute to the creation and support of new centers – “national twinning programs” – an alternative model to be explored.

**Recipient selection:** Although some of the following recommendations were included in PART I of this article, it is pertinent to reiterate them:

- To avoid squandering energy and resources it is important to identify places, “fertile sites”, and their needs, with receptive individuals where good work is already being done.
- The majority of donor programs focus on developing an on-going relationship with a host program. This relationship involves visiting teams, teaching, training, collaborative research, and donation of equipment.
- Twining programs in Pediatric Cardiac Surgery. These “twinning processes” result in a transfer of knowledge, ideas and skills. A visiting team usually includes: surgeon, anesthesiologist, cardiologist, perfusionist, critical care specialist, interventional cardiologist, and nurses.
- Do they work? Yes, in selective places with the potential of eventually becoming autonomous, with the donor program assuming a consultant role.
- This strategy is based on a long-term educational and technical support model.
- This approach will be most effective when local governments, doctors, and hospitals have a genuine learning interest.
- It is important to using metrics and evaluations as a tool for learning and sensing the feasibility of the project.

### **Domestic Philanthropic Endeavors**

Philanthropy in the developing countries is suboptimal and has no solid tradition. Latin America, predominantly

Catholic, the world’s most unequal region, is a good example of relatively modest philanthropic efforts with many opportunities for leadership.

Culture and/or interpretation of the concept of philanthropy may be responsible for weak philanthropic efforts. In the United States philanthropy is mainly the donation of money for a good cause. In other parts of the world where money is scarce, people donate their time and skills to help other persons without expecting personal benefits.

Lack of tax incentives and tax evasion also has a negative impact on philanthropy and charitable donations. Even when tax incentives are available, deductions are only possible for the minority that pays taxes. In addition, lack of trust and accountability are powerful deterrents.

However, not everybody is poor in the emerging countries. There are often people with enough education and resources to organize and participate in local philanthropic efforts, to help their own “have nots”. The philanthropic leadership will come once the elites have the opportunity to cross the physical and psychological barriers that make it difficult to get to know the poor, recognizing them as fellow citizens. Philanthropy can also add to the total sum of efforts necessary to rescue the education systems.

**Basic Requirements:** After analyzing concepts and theories, we can now move to the practices required in our daily work such as:

- **Institutional enabling support:** Needless to say, this means enabling the faculty to do the work through the active participation of those on the top in addressing and resolving other limiting factors which can eventually reduce the number of binding constraints — thereby, with synergy, creating the mutual benefit of changing for the better in a partnership. High quality institutions provide the required enabling support to achieve better care in cardiac surgery.
- **Integrated approach:** Team work exist when all members of the cardiovascular services — a cluster of people with similar interests and focused on excellence — contribute, although in different degrees, to the quality of the final outcome; in another words, the members of the team show the willingness to face reality and agree to do adaptive work throughout the organization.
- **Volume for a safe and sustainable care:** Many hospitals want to have a pediatric cardiac surgery program. It might be that this is a specialty that has to be done only in centers with enough volume [2]. A minimum of approximately 100 surgical cases per year, with the potential to increase to 300 cases per year or more over an approximate 5-year period, is needed to ensure that heart surgery is not being carried out on children where the low volume of patients or other factors makes it unsafe to perform such surgery. National standards should be developed, as a matter of priority, for all aspects of the care and treatment of children with congenital heart disease.

• **Diagnosis and Treatment:** 1) Pediatric cardiologists and related specialties; 2) Congenital cardiac surgery, 24/7, with 100 pediatric cardiac surgery procedures per year/surgeon as a minimum; 3) Congenital cardiac anesthesia 24/7; 4) Nursing (24/7); 4) Interventional cardiology 24/7; 6) Other allied health services such as perfusion, social work, pharmacy, blood bank 24/7.

• **Pediatric Intensive Care:** Preoperative evaluation and optimization of patient condition; postoperative care 24/7.

• **Follow-up and application of methods for meaningful comparisons of in-hospital mortality for groups of children undergoing surgery for congenital heart disease:** such as the Risk Adjustment for Congenital Heart Surgery (RACHS-1) methodology or the Aristotle Basic Complexity Score (ABC Score) and Aristotle Basic Complexity Levels (ABC Levels).

• **Utilization of the clinical material:** for contributions to professional society's national and international journals. Make the best and most effective use of their organization's resources.

• **Open mindedness:** Institutional sclerosis is a major obstacle to progress. In those institutions with rigid structures, all of their tenured staff should cooperate, be prepared to compromise and agree to work toward these basic requirements, using the method of self criticism and rectification to address not only technical issues but also dysfunctional behaviors. Human factors — especially those affecting interpersonal relationships, interactions and collaboration — are frequent causes of lasting problems [3]. *“Minds are like parachutes. They only function when they are open.” Sir James Dewar*

### Rethinking the Adult and Pediatric Cardiac Surgery under one roof

**An outdated model at a crossroad:** Up to the late seventies, most of the new developments in cardiac surgery were coming out of centers doing both adult and pediatric work. By 1975, ten percent of the patients coming to operation were within the first 6 months of life and 19% were within the first 12 months of life. Currently, around 60% of the patients are operated on their first year of life, and 30 % in the first month of life [4]. This trend — the movement of pediatric cardiac surgery to the very young — has developed because of the numerous biological and socio-economic benefits of early repairs, as well as the excellent outcomes that are being obtained particularly in pediatric cardiac surgery centers as a result of an ongoing generation of knowledge.

“In some specialties, such as pediatric cardiac surgery, clinical practice has become so sophisticated and the technology has become so advanced that those patients who would otherwise have died only 10 years ago can now be safely treated with confidence” [5]. In addition, hospital admissions for adults with congenital heart disease are increasing at a higher rate than for children, supporting the need for optimizing health delivery for adults, as the drift in

increased hospitalization is expected to persist into the near future. We need to flex new muscles as the demands of the business environment are changing.

**One size does not fit all:** In the current era, it is an artificial construct cemented together by an elite that ignores the increasing trend for sub-specialization in both fields and the challenges around the safety and sustainability of these services in the future. Rather than artificially repressing them, those institutions in which pediatric cardiac surgery is combined with the adults program need to understand the differences in the business plan, paths, manpower, mindset, training, and infrastructure of both disciplines.

It is possible to modernize the structural needs of outdated institutions by applying the concept of *spatial thinking*, a cognitive skill that can help in understanding the world around us by using the properties of space in everyday life, the workplace, and science, to structure problems, find answers, and express solutions. In a case of co-habitation, it is helpful for *analytic* purposes, to develop a modern *vision* based in a constructive co-existence — to exist in peace with others at the same time or in the same place despite differences — preserving the necessary connectivity to solve common problems.<sup>1</sup>

Furthermore, spatial thinking is also a *tool* to consider for designing a structure with core groups of dedicated specialists — human capital — covering critical areas in which different practices and protocols are required, such as surgery, anesthesia, intensive care, and perfusion.

While preserving their identity, this approach can improve the quality and the efficiency of the services by finding paths to allow synergies among all disciplines involved, thus avoiding a “perfect storm”, an event where a rare combination of circumstances will aggravate a situation drastically. Such a significant change can only succeed with a strong bottom up leadership, involvement, and cooperation. Open governance should facilitate the integration. Closed means a small non-responsive and non-expandable number of decision makers.

The context should determine the strategies and processes to address these issues, and what parts of the professionals, administration, and professional societies should be engaged in planning, setting and articulating the goals and participating in the negotiations.

As Charlene Barshefsky, Great Negotiator Award Winner, reminds us: *“The goal tells you what you need to know. It informs who should be at the table, and which parties are extraneous.... If the goal is framed too broadly, the results are likely to be ambiguous and unenforceable.”*

In other words, critical thinking is fundamental to understand the limitations of the current model and to address creatively and effectively the needs of the users with a long

1. Karen Lee Bar-Sinai, “The role of architects in negotiations” Harvard School of Education. Cambridge, November 20, 2012.

term objective. Then there should be a path to execute and reach that objective that can be frequently evaluated and adjusted accordingly.

Compromise can minimize the resistance that might be encountered in implementing the recommended strategies, and help to reach an agreement with a smooth transition, allowing differentiation with advantages for the various components of the system. Work groups ought to consider what should be the design of each program and how this should be enacted — all at once, phased-in, etc. The majority adult cardiac surgeons (number of cases) need to learn how to make their minority pediatric colleagues feel that they are a pillar of the governing structure. Minority pediatric surgeons must embrace their place in the new structure by becoming fully contributing partners while leaving behind any ill sentiments.

Because things always change it is important to take measurements to know what the differences are.

“This institutional decision needs to be made in a framework of deep reflection, commitment to the well-being of each individual patient and requires considerable study and integrity” [4].

#### **Neonatal Surgery: an example of complexity**

The frequent advances in the diagnosis and treatment of congenital heart disease during the last two decades have changed the way these patients are currently managed. Neonatal heart surgery aims at the prompt anatomical and physiological restoration of the anatomy and physiology, or seeks the best feasible palliation, in order to improve functional capacity and life expectancy. In this particular field, the progress in multiple medical and technological areas allows successful early surgical approach to complex pathologies that carried a devastating mortality not long ago. In order to obtain the best possible results and minimize the multiple risks involved in this practice, various considerations have to be taken into account. These are related to the institution where the surgery takes place, the human resources available, and the particular characteristics of the new born patient that presents distinctive critical issues that deserve a few words of caution, including:

- Preoperative circumstances requiring a preoperative management according to the anatomic and physiological variants.
- Limited physiologic reserve — organ immaturity — lungs, liver, kidneys.
- Transient organ dysfunction: cardiac, respiratory, renal.
- Known complications and/or consequences related to cardiopulmonary by-pass (CPB) that is unique because of immaturity.
- Diverse and complex physiopathology of the cardiac lesions.
- Prematurity and low birth weight (2.5 kg or less).
- Complex surgical procedures and risks of residual

problems. For example, poor cerebral protection can have catastrophic consequences for the patient, the family and the society, such as poor outcomes in learning, behavior, and both physical and mental health. As Shonkoff has made clear, “Every second, a baby’s brain makes 700 new synapses. These connections can be strong or faulty and once made, they cannot be rewired. Early events shape the architecture of the developing brain” [6].

In spite of these particular handicaps an early approach to the initial phase of repair should be attempted whenever possible, since leaving these patients untreated or unnecessarily delaying surgery, contributes to high mortality. To mention only two important neonatal heart problems, for both transposition of the great arteries (TGA) and hypoplastic left heart syndrome (HLHS), a surgical repair performed in the first days after birth has dramatically modified the natural history of these malformations. This progress is well explained in Brooks’ definition of path dependence which refers to the notion that often “something that seems normal or inevitable today began with a choice that made sense at a particular time in the past, but survived despite the eclipse of the justification for that choice” [7]. The operative mortality of HLHS was as high as 40% in the 1990s and has dropped to less than 10% recently [8].

Although the accuracy and quality of the surgical procedure are the most important determinants of survival after surgery for neonates and infants, in addition to early diagnosis, capabilities for transportation and pre-operative resuscitation, require expensive sophisticated support, expertise, manpower, and advanced technology. Given that this cohort of patients has a limited physiologic reserve, complex cardiac lesions that often require technically demanding procedures, and are prone to complications and/or residual related to cardiopulmonary bypass, they are an example in which complexity demands complexity. In all fields there is a residue of anomalies unexplained by the dominant theory. Unsolved observable facts do not necessarily nullify good theories. It just means that more work needs to be done to bring those anomalies into the accepted paradigm.

Neonates face unique incremental risk factors related to the patient’s variables and to structural hospital characteristics that should be properly individualized and addressed in a timely fashion in order to improve surgical results. The development of a successful neonatal heart surgery program requires institutional quality, medical expertise and resources — an integrated approach — in which every component of this complex system (individuals, activities, connections, and pathways) should be activated. In other words, a meaningful institutional commitment and staff partnership is necessary to meet the current demand for excellence.

Because individual medical leadership and skills are not enough to solve these problems — a puzzle with multiple challenges — neonatal cardiac surgery will linger last in



most developing countries. Well-trained and skillful surgeons, while being able to generate excellent results in children, have difficulties reproducing the same kind of outcomes with neonates and infants. I am mindful of the danger of being unjust to people who make choices in conditions of uncertainty and circumstances over which they often had little control. It will require efforts at multi-levels of national governments — leaders with a passion for reducing suffering, capable of changing minds and mental models — and civil society to face reality, adjust values and priorities causing social exclusion, and the need to overhaul the health care system. Institutionalizing change is not an easy task but it is probably the road to sustainability [1].

#### **Ethics, experience, decision making for children, and risks**

Recognition of institutional and individual limitations is imperative for ethical pediatric cardiac care. “When confronted with an ethical dilemma, most of us like to think we would stand up for our principles. But we are not as ethical as we think we are. We overestimate our ability to do what is right and how we act unethically without meaning to. We can become more ethical by bridging the gap between who we are and who we want to be” [9,10].

**Experience matters:** The more experience physicians and teams have in treating patients with a particular disease or condition, the more likely they are to create better outcomes — and ultimately realize lower cost. By performing particular procedures over and over, teams increase their learning opportunities and thereby reduce mortality rates. Having to think about everything each time leads to imperfect performances. Although procedure volume is relevant, other institutional factors can also contribute to the quality of outcomes. Recognition of institutional limitations is imperative for ethical patient care [11].

**Decision making for children:** At the beginning and at the end of life, children and elders are not part of the decision-making process regarding procedures, risks, or by whom, and where the care should take place. Therefore, adults, parents, and doctors making decisions for them should be aware of their responsibility by including in their considerations the information available regarding risks, prognosis, suffering, quantitative improvement, and long term quality of life.

**Talking about medical risks, the uncomfortable truths:** What duties and responsibilities arise with regard to the physician-patient/parents relationship? Should patients and parents be told of better care elsewhere? [11]. Notwithstanding that some people prefer to be treated close to home even if the risks are higher there, patients are not often told during the informed-consent process that the results of treatment can vary among hospitals and the volume-outcome relationships, particularly for those requiring complex risky procedures. Often, patients and families get some numbers from the literature, but very few physicians sit down and

tell them what their own complications and success rates are. The question of what the doctor’s obligation is remains unresolved.

#### **Statistical evaluation and comparison of results:**

*“No human investigation can claim to be scientific if it doesn’t pass the test of mathematical proof”*

*Leonardo Da Vinci*

Repair of congenital heart anomalies involves an enormous anatomic variety and offers a diversity of surgical procedures of different complexity that makes a comparative analysis of mortality and quality of results very difficult, even within the same center or among different centers or regions. Often, comparison it is not about how bad you are, but rather about how good others are. Meaningful quality of care evaluation needs to take into consideration the variations of the population — the so called “case mix”. This concept is less important in the adult population due to significant differences in the size of the samples and the diversity of operations [12]. The statistical analysis of crude mortality without taking into consideration case mix complexity is inadequate for comparison and erroneous in itself. Neonatal evaluation carries an additional challenge due to the small numbers and the larger diversity of the procedures.

In January 2002, Jenkins & Gauvreau [13] reported a new and original consensus-based method called RACHS-1 (Risk Adjustment for Congenital Heart Disease) which permits a meaningful and adjusted comparison of mortality in children undergoing surgery for congenital heart disease. Two years later, Lacour-Gayet et al. [14] reported another method called “The Aristotle Score”: a complexity-adjusted method to evaluate surgical results.

**Risk Adjustment for Congenital Heart Disease (RACHS-1):** This method was developed to adjust for baseline case mix differences in comparisons to discharge mortality among pediatric patients less than 18 years old. The surgical procedures were classified by a panel of 11 experts (pediatric cardiologists and cardiovascular surgeons) into six categories, 1 being the lowest and 6 the highest risk of expected in-hospital mortality, based on information obtained from the Pediatric Cardiac Care Consortium (PCCC) with 4,370 surgical procedures done in 32 hospitals and the American Hospital Discharge data.

This classification is based on the type of surgery rather than on the anatomical diagnosis; for example, in the sequential surgical approach of the HLHS, the first surgical intervention (Norwood procedure) has a risk 6; the second step, the connection of the superior vena cava to the pulmonary artery (bidirectional Glenn) carries a risk 2, and the final surgical intervention (total cavo-pulmonary connection) a risk 3.

This system, used to predict mortality and risk adjustment in pediatric cardiovascular surgery constitutes a valid tool

to compare the results between different health centers and has been statistically validated worldwide by several authors [15-18]. There is a vast literature referring to the benefits and limitations of both methods, which are at present being used in many institutions all over the world. Moreover, there are currently studies in progress to improve them, adding new elements such as standardization of morbidity measurements and a new development of complexity stratification system based on objective data (the sum of mortality, and morbidity) and subjective technical difficulty [19-21]. Understandable data and analytic leaders — individuals who are at ease with numbers and able to explore solutions based on a rational analysis of complex issues — are needed.

***Risk stratification for adult congenital heart surgery:***

This is a large and growing group of patients that require different business models, mindsets, and pathways than the one in use for the pediatric population. Currently no risk stratification score is available for adult congenital cardiac surgery. The discriminatory power of the pediatric risk scores are suboptimal for the adult population, but improve when adding age as a score component. A best performance can be achieved by the combination of age and the Comprehensive Aristotle Score, for both 30-day and 1-year mortality. Proper risk stratification scores for this cohort of patients will be useful to decide who should treat them and where [22,23].

**Leadership and culture**

Leaders are individuals who significantly affect others, transforming the way the individuals with whom they come in contact think and go about doing things. They lead by their example; therefore, it is important to recognize that no matter how good you are, you are only as good as the people who are working for you and how good you are developing them. If leaders tell one story but lead contradictory lives, they are hypocrites. A leader is best when people barely know he exists. He is not so good when people obey and acclaim him. But he is worst when they despise him. But of a good leader who talks little, when his work is done and his aim fulfilled, they will say: “We did it ourselves.” (*Lao-tzu, 6<sup>th</sup> Century B.C., Chinese Philosopher*)

It is important to understand medicine, health care, illness and disease from a socio-cultural perspective. What is medically obvious in one culture might be incomprehensible in another. What is possible in a rich country might be almost impossible in the developing world regardless of authority, leadership and technical competence.

Having worked in South America, Europe, and most recently in the United States, I have found that the differences in culture, resources and technology have had a significant impact in my practice and interactions with colleagues, patients and the public. In complex cross-boundary interactions, it is difficult to assess risks and make decisions requiring the calculation of the probability of outcomes and the prediction of

people’s behavior. It is difficult to judge anything at all without walking a few miles in the other person's boots.

My leadership challenges in my home country and abroad — where I always tried to lead from the middle — resulted in a mix of successes and failures. Like everybody else, I have made my share of mistakes, related at time to insufficient resources, my personality, my emotional intelligence, the feasibility of the task, the limitations in my authority and sometimes not enough knowledge of the local cultural narrative. Effective leadership from the middle is possible but can be extremely difficult and even impossible when those holding the platforms of power at the top are not receptive. This means that a good leader in the right place at the right time still might not necessarily save the day.

Politics is about leadership and the ability to get things done. Actions in addition to words! The elasticity of reality describes the relative size of the principle/rhetorical-implementation/reality gap, resulting in poor implementation of good ideas—a concern about the growing skepticism of future rhetoric. Yet as the gap between reality and rhetoric expands, the risk increases that the public will grow skeptical of future oratory.

**Challenges facing cardiac surgeons and the science of cardiac surgery**

“Together, as it was the case in the recent past during which enormous progress was made — the list of achievements is long — we need to bring our specialty into a brighter future, it must be something we cannot possibly do!” [24]. We have been able to see so far because we stood on the shoulder of giants. Therefore, we need to nurture our youth in order to give rise to a new generations of giants that will prolong the path to success. Their tools being commitment, technology, creativity, and learning how to learn by cultivating their ability to ask questions that include cause and effect, the cornerstone of critical thinking. In addition, collaboration with other sciences by breaking down the boundaries around academic disciplines, and by strengthening the capacity to adapt, can play a role in finding answers for a future that seems to have no limits. In other words, we must continue to be a resilient system in the face of the inevitable new stumbling blocks — problems or difficulties that stop one from achieving something. However, the history of complexity research indicates that our can-do optimism should always be tempered by caution [25].

**Inferences**

- Talking directly about problems is risky because most people do not like it.
- Enumerating the problems may be easy, finding the solution is proving increasingly difficult in settings without political stability and sustainable economic growth.
- We do not have yet the clout — due to lack of cohesion — to advocate successfully for our “orphan” pediatric

cardiovascular services particularly in the developing world.

- It is important to determine what should be preserved, what needs improvement, how it can be done, by whom, and what we must transform [26].

- Those institutions in which pediatric cardiac surgery is combined with the adult program need to understand the differences in the business plan, paths, manpower, mindset, training, and infrastructure of both disciplines. Each group's bosses should have a clear understanding of what they want from the alliance before signing up. Most important is gaining support at all levels of each discipline for working together.

- We need to improve the quality of the decisions we make. How we decide often determines what we decide.<sup>2</sup> Ask yourselves, what strategies and processes would you advise to overcome these problems, and what parts of society and other professionals would you want to engage to aid the process? What problems do you expect might be encountered in implementing the recommended strategies? [27].

- Centers of development with the necessary funds and manpower for research to generate new knowledge, particularly in the field of rare diseases, and adults with congenital heart diseases, may be needed for a more efficient treatment, cost benefit ratio, and sustainability of the care. These centers can then disseminate the new knowledge, minimizing or even eliminating the learning curve and develop policies for the future of the specialty [28].

- These centers, can improve their analytic capabilities through adding estimative intelligence to gauge uncertainty and make assumptions about different scenarios, to anticipate the consequences and probabilities [29].

### Final thoughts

Some readers may consider this paper “philosophical”. If we accept that philosophy — the base of critical thinking — is “*The critical analysis of fundamental assumptions or beliefs*”; “*A set of ideas or beliefs relating to a particular field or activity*” or “*A system of values by which one lives*”, it could be rightly regarded as philosophical. However, I thought that the title of “Philosophy of Cardiac Surgery” may not sound attractive to the surgeons’ mindset [30].

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