Rev Bras Cir Cardiovasc 2013;28(1):129-36

Cardiac surgery: the infinite quest. Part II

Cirurgia cardíaca: a busca infinita. Parte II

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Publicamos, abaixo, a segunda parte do artigo "Cardiac surgery – the infinte quest". Apesar de mais complexo que a anterior, este texto vai além das habilidades técnicas e tem conceitos modernos de como lidar com os sistemas complexos da atual prática da nossa profissão e especialidade.

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Editor-Chefe/BJCVS/RBCCV

DOI: 10.5935/1678-9741.20130016

RBCCV 44205-1449

Part II

Cardiac surgery: issues around and beyond the operating room

Ultramini-abstract: *In addition to our clinical and technical work, there is a need to cross boundaries searching for collaboration as well as lessons from other complex systems that has identified common solutions for common problems, indicating that the general theory is independent of any particular industry or activity.*

Cardiac surgery: a complex system

Heart surgery has much in common with other high technology systems in which performance and outcomes depend on multifaceted interactions of individual, technical and organizational factors. In addition, our specialty often functions as a chaotic/emergent system since the initial circumstances vary in patients with the same medical condition resulting in uncertainty and lack of predictability [1].

Complexity: The American Heritage Dictionary defines complex and complicated as "things whose parts are so interconnected or interwoven as to make the whole perplexing". If we add rarity and small numbers to complexity, the results is a distinctiveness that explains many aspects of our profession and specialty such as variability with institutional differences in outcomes; inconsistency of results in treating rare diseases and uncertainty on any inference about results of complex rare lesions [2].

A system is a set of interdependent elements that are interacting, or working together, to accomplish a common goal. All systems, at the "atomic" level, consist of individuals, activities, connections, and pathways with the following characteristics, qualities or peculiarities in complex systems:

• Heterogeneity of the parties (diverse nature and multiple);

• Cause-and-effect relationships may be nonlinear and obvious only in retrospect;

• Richness of interaction between them (including their contradictory character);

• Multidimensional and multi-referential;

• Many variables commonly present;

• Provide information that by itself reveals the extent of its complexity;

• Under an apparent simplicity, they often hide the true dynamics of these processes and interactions between its parts

• Vulnerability — Are influenced by factors and surprising circumstances that may affect, cause, or facilitate a change in behavior and expected results, altering all or changed significantly

"Complex business generates complex services. Regardless of how much effort and brain power go into designing their complex operations ('system of work'), it is impossible to do it perfectly and to predict how it will behave under every circumstance" [3].

Complex systems are rich in multiple and interdependent

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Article received on January 31st, 2013
Article accepted on February 28th, 2013

events that usually manifest unforeseen consequences that are nonlinear and often asymmetric — frequently called black swans. Why call big surprises black swans? It goes back to the second century when Roman poet Juvenal said that some events are "as rare as a black swan" [4].

History is shaped by events that seem impossible until they occur changing predictions and planning. Surprises are by definition unexpected and therefore well beyond the limit of our experience, not allowing us to pick the "next disaster". Why can't we foresee these events? Blame it on the way humans make sense of the world — most of their experience falls within a tightly bounded range called "the norm". Focusing on that narrow array carries the risk of preparing us only for events we are familiar with [5].

Rare diseases — rare as Black swans — are a challenge for the Science of Cardiac Surgery because of their infrequency at any single institution, and thus the gaps in knowledge. Because of this, there is little chance that randomized comparison can be accomplished. In this setting, highly variable outcomes are predictable given the scarceness of skill-based, rule-based, and knowledge-based foundations for performance that avoids and compensates for human errors, the inevitable breakdowns due to complexity and uncertainty. Statistics to determine risk are not available; we just do not have them due to their rarity.

Complexity thus calls for experimentation. Once patterns become apparent, it is possible to attempt to destabilize undesirable interactions [6]. By contrast, in *chaotic* situations — highly sensitive to initial conditions — there are no trends to monitor. Sometimes complexity is at the "edge of chaos" without a pattern to differentiate.

Clayton Christensen reminds us that "Theory is often associated with the word theoretical, which, among practical people, has a connotation of impracticality. However, a well researched theory is practical because it allow us to know what cause what and why, and to predict the result of an action. The key to developing a theory that is valid internally and externally is to seek anomalies, to find instances in which the explanation of causality does not yield the result that the theory predicts. The scientific method requires to search for instances in which the theory does not work" [6]. *"As the circle of science grows larger, it touches paradox at more places" Nietzsche*.

Managing complexity: Steven Spear aptly describes the problem and manner of managing complexity: "There are *high velocity organizations* — whom everyone chases but never catches — that manage to stay ahead because of their endurance, responsiveness, and an exceptionally high velocity in self correction. They see and seize opportunities and, by the time rivals responded, the leaders have raced on to further opportunities — these systems pose both the capacity to retain their viability and the capacity to evolve" [3].

"These organizations — complex adaptive, self-improvement systems — face a common problem and have identified a common solution, which keeps them performing way ahead of the pack and always getting better — the two go together. The solution has been used successfully by a wide variety of organizations indicating that the general theory is independent of any particular industry or activity" [3,7].

"And this leads to collaborative rationality, of getting better together, which is a different way of knowing and generating, of making and justifying decisions based on *diversity, interdependence and authentic dialogue* — not always accepted by the chain of command despite of the limitations of acting unilaterally. The agents interact dynamically, exchanging information and the effects of these connections flow through the system. There are many direct and indirect feedback loops; the overall system is open. The behavior of the system is determined by these interactions, not the components; and the behavior of the system cannot be understood by looking only at the components" [7,8].

Diversity: "Diversity implies that a collaboratively rational process must include not only agents who have power but also those who have needed information or could be affected by outcomes of the process". As in direct democracy, their success depends on the amount and quality of the information available to those involved in the decision making process [9,10].

Interdependence: "Agents must depend to a significant degree on other agents, considering that each stakeholder has something that the others want. This condition ensures that participants maintain a level of interest and energy required to engaging each other and pushing for consensus — such interdependence means that players cannot achieve their interests on their own" [10].

Authentic dialogue: "Deliberations must be characterized by direct engagement so that the parties can test to be sure that claims are accurate, comprehensible, and sincere. Deliberations cannot be dominated by those with power outside the process, and everyone involved must have equal access to all the relevant information and an equal ability to speak and be listened to. In authentic dialogue, nothing is off the table" [10].

Structure and dynamics of successful high velocity organizations

Structure: Managing and integrating the functions as part of the process.

Dynamics: "Continually Improving the Parts and the Process, by engaging those closest to *the work in the continual improvement, their speed of detecting and problem solving*, learning, and discovering better ways of how to produce. Any snapshot will reveal where they are today but not where they are headed determined by their DNA".

"These organizations, share four capabilities that can be adapted to medical situations: a) specifying design to capture existing knowledge and building in tests to reveal problems and improve a process; b) detecting and rapidly solving problems to build new knowledge avoiding memory perishability; c) sharing new knowledge throughout the organization; d) leading by developing the above mentioned capabilities by allowing enough time and resources for staff/team training, turning employees into problem solvers. Operations are designed to continually let them know that it does not know all there is to know. When the operations speak, these organizations listen, learn, improve, and wait for the next lesson. The lesson learned here and now is spread throughout the organization. The high velocity set themselves apart in how they deal with the problem of unknowable unpredictable systems, understanding, learning and recovering from failures" [3].

How complex systems fail: in those systems that fail, their pieces come together through hard work, goodwill, and improvisation. Their components are managed as if they operated independently; in fact they are quite interdependent. Although it could be a "Sisyphean task" some of them fail wisely learning from their mistakes and try again. However, the choices are often both clear and stark: organizations must either modify their forms and structures (reinvent) in ways appropriated to the emergent environment or, over a period of time, cease to exist. Occasionally, disruptive innovations, creating new organizations are necessary rather than transformation of existing outdated institutions.

Like in our profession, the first step to treatment is diagnosis. If one considers that a system has an illness — dysfunction — the first step should be to make a diagnosis to uncover its root causes. Often, administrators and managers have a tendency to prescribe treatment without a proper diagnosis that would allow identifying the system-specific problems. Policies that work in some setting may not be effective in a different context. A chart constructed by combining a diagnostic tree with the National Diamond Model allows displaying the components of the system and pinpointing the potential binding constraints affecting performance and growth before implementing reforms. A similar approach, with different factors, can be used in program evaluations [11,12].

There are many factors which contribute to failed or failing institutions [13].

Reasons people fail

• **Personal weakness** — failure to reach a minimum required performance;

• **Poor people skills** — inability to relate to others;

• **Deviance** — violating an agreed process or practice;

• **Negative attitude** — in reacting to adverse circumstances of life;

• **Bad fit** — mismatched abilities required to execute the job, interests, personality, values;

• **Lack of focus and attention** — priorities not well established leading to inadvertent departure from stipulations;

• **Weak commitment** — not giving the task our very best;

• **Unwillingness to change** — major enemy of success;

• **Shortcut mind-set** — take the shorter road to success;

• **Excessive confidence** — it is not beyond my scope or skills. I can do no wrong → Ego;

• **Relying on talent alone** — avoiding hard work to improve it;

• **Response to poor information** — not feeling you need more information;

• **No goals** — lack of a dream with a time limit;

• **Frustration** — not learning from failures;

• **Anger:** according to Aristotle, *"Anyone can become angry, that is easy — but to be angry with the right person, in the right degree, at the right time, for the right purpose, and in the right way — that is not easy"*. Rationally speaking, it is a very important emotion and a huge driver of human behavior. In some cases it is even welcome; however, those that can control it — i.e., those who have emotional intelligence or are emotionally astute — avoid being an angry decision maker and may have an advantage in their daily life. In sum, showing your anger conveys a toughness that can help you get what you want. But beware: When your counterpart has better information than you do, your anger could work against you [14].

Human behavior and errors: Medical errors cause 90-120,000 preventable deaths per year in the USA — *far more than in car crashes* — costing the industry somewhere between $9 billion and $15 billion a year.

Furthermore, only 50% of US patients receive adequate quality of care, altogether enough to take the necessary actions to reduce risk the factors. It is a basic principle of systems that every one of them is perfectly designed to achieve the results it attains. Academics, by studying these systems, could contribute to a better understanding of how the components relate to one another in designing a self improving process that prevents mistakes from occurring. In addition, medical schools should consider building up awareness of the importance of prevention of medical errors among students early on their career [6].

The fact that complexity makes errors inevitable should not be an excuse; we should to do our best to avoid them. Human factors research has been a major contributor to safety, enhanced reliability and error avoidance in those complex socio-technical systems such as the *aviation industry*. Their long used safety check list looks like a simple and helpful tool to reduce errors, complications and deaths in medicine, as well as in other professions [15]. Unfortunately, industry and watchdogs often rely far too much on a patchwork of retroactive rules, with inspectors adding the negative event to their checklist each time a trouble is found in one of the components, decreasing its usefulness, particularly if thereafter the new norm is looked at with the old lenses.

Imperfect outcomes are caused not only by lack of knowledge — ignorance — but by imperfect selection of treatment, imperfect performance, and are too often caused by human errors. Mistakes are the result of either the misapplication of good rules — ineptitude — or the application of bad rules. Most mistakes can be traced back not just due to flawed execution but to flawed thinking of people trying to do a good work, and a tendency to make absurd decisions [16]. Team communication, organization, and mutual supervision are crucial to minimize the chance of making a mistake.

Technical failure and human error led to the loss of an Air France flight over the Atlantic in June 2009 and the deaths of 228 people, according to the final report of the French air accident investigation agency (*Pilot Linked to Air France Atlantic Plunge, BBC News, July 5, 2012*). Similarly, the Fukushima nuclear plant was "a profoundly man-made disaster that could and should have been foreseen and prevented" and its effects "mitigated by a more effective human response" according to the report of the Japanese parliamentary panel. The report catalogued serious deficiencies in both the government and plant operator response adding that regulators should "go through an essential transformation process" to ensure nuclear safety in Japan (*Japan panel: Fukushima nuclear disaster 'man-made'. BBC News, July 5, 2012*).

It is important to recognize that medicine is so complex that no human being can be in control of everything without some sort of compensation for bounded rationality or hyper rationality. Furthermore, over the last decades, science has filled in an enormous amount of knowledge, challenging even more the human mind's limited capacity to evaluate and process the information available, considering the time constraint to make some decisions. We have to achieve near perfection in the shortest possible time avoiding the "let's-get-home-itis", a disease in judgment that has negative impacts on a number of surgeons who sing the praise of speed and quick operations.

It may be part of human nature to err, but it is also part of human nature to develop solutions, find better alternatives, and meet the challenges ahead. Rather than punishing those that make mistakes, it is more effective to find out why they made the mistakes in order to act on the system to diminish the odds of repetition [17].

Negative events in complex systems

Minor Events are subtle, insidious, except to human factors observers, and many of them largely overlooked by the operator and the team members. As a result, no attempt to correct them is made. In isolation, they have little impact, but their multiplicative effect can lead to negative outcomes.

Near Misses can cause severe temporary or permanent complications. By paying attention to close calls, it is possible to recognize them, learn and eventually predict and prevent major events. Unfortunately, decision makers have often a tendency to view near-disasters as successes!

Major Events, without compensation, are likely to lead to death. Because they are more obvious, they can be recognized, triggering rescue actions to avoid catastrophic consequences.

Risk Factors for Complications are more related to patient variables than to structural hospital characteristics. The highest quality, lowest risk hospitals have a higher prevalence of rescue from complications. It is the failure to compensate that leads to a negative outcome [18].

Individual and organizational factors and their interactions

Individuals: Exchanges with highly qualified individuals concerning change often involve negotiation and compromise, since they would not comply with the instructions without adequate rationale. It is not a matter

of who is right or who is wrong; the focus must be on what professionals should care about: the patient.

Though silence is associated with many virtues, it can exact a high price on individuals, generating feelings of humiliation, paralysis, anger and resentment, and eventually, if unexpressed, can seriously damage an organization. Silence can also be the result of cultural conventions and a reluctance to question authority.

The message throughout the organization should be: STOP! Any question from the team? *"If you see something that concerns you please speak up"*. It is difficult to manage secrets! This approach thwarts the blame game, helping to build a culture that promotes participation, and encourages detecting, analyzing, and learning from failures [19].

Organizational factors: Team work in which all components of the cardiovascular services — a cluster of people with similar interests, all focused on excellence — contributes to the quality of the final outcome with an integrated approach.

Using an orchestra as a paradigm of team work, a conductor — the chief cardiac surgeon in most centers — leading from the front and by example is *needed*, working out the problems collectively with the individual orchestra members. He does not produce the sound but he can inspire, teach, and persuade. It is about how to play rather than what, an excellent example of the importance of coaching something that surgeons seldom do.

After all, "Music fills a gap in life like nothing else — and brings serenity when other things cannot" [20].

Interaction, negotiation and compromise: In an ideal world, after an operation, patients stay in the intensive care unit where the physician on duty must synthesize information from various sources and personnel into a sound plan of care. When another physician, such as the cardiovascular surgeon — when they participate, though often they do not — collaborates with the critical care specialist to manage a patient, the relationship requires mutual respect and cooperation, without patient ownership, in order for optimal patient care to occur. If the dialog starts with someone saying: this is my patient! It is a bad start. Every agreement in the ICU involving two physicians is a negotiation as much as it is collaboration. Each person concerned approaches the interaction with a defined (and possibly different) idea of what he wants to happen, and therefore there is an urgent need to reach agreement on a plan of action. If you approach a negotiation thinking you know everything, you may not make the best decisions. You could be missing out on information, insight and suggestions that may be critical to the outcome. A leader who doesn't nurture an atmosphere where ideas are welcome is shortchanging his or her effectiveness. In addition, team members who are discouraged from giving opinions or input will be ineffective players.

It is prudent to approach these discussions with a few ground rules in mind. *First*, there are certain basic principles of care known to be true that should not be compromised. *Second*, both parties will learn something from the interaction. *Third*, there is much in medicine that is either uncertain or can be approached in more than one-way. *Ultimately*, the best plan more often than not results from honest open communication between physicians and the melding of the best of both points of view. If beyond winning, both physicians enter into the negotiation accepting that give and take is essential to the process, then a well reasoned design of care is achieved and the patient benefits greatly. An analogous approach is applicable to the interactions among surgeons, cardiologists, anesthesiologists and perfusionists. It is difficult to have a team unless every member has respect for people who have different skills [21,22].

The power of a positive NO: "No is perhaps the most important and certainly the most powerful word in the language. Every day we find ourselves in situations where we need to say *No* — to people at work, at home, and in our communities — because *No* is the word we must use to protect ourselves and to stand up for everything and everyone that matters to us".

"Saying *No* the right way is crucial. A wrong one, a clear a resounding *NO*! can also destroy what we most value by angering and alienating people. The secret to saying *No*, clearly, respectfully, and effectively, without destroying relationships lies in the art of the Positive *No*, a technique that anyone can learn. The Positive *NO* can help you to get not just any *Yes* but to the right *yes* the one that truly serves your interests" [23].

Quality: "An essential and distinguishing attribute of something or someone" (*Word Net Dictionary*). It is difficult to define, but you know it when you see it! Quality is measurable and requires appreciation to recognize the quality, its significance or magnitude and appreciation requires knowledge.

In medicine as in many other businesses *precision* equals precise diagnosis plus doing the right thing (effectiveness) plus doing it right the first time (efficiency). Precision in medicine not only improves outcomes but also can dramatically cut costs. In health care, cost is not a proof of high quality and low cost comes from focus. Value added procedures are possible only after a precise definitive diagnosis has been made [6,24].

Quality comes from correct integration to get the job done. As we improve the technology of medicine, we also need to include the patient's story in the equation: ***Quality of care*** equals ***technical quality*** (precise diagnostic, doing the right thing and doing it correctly) plus ***service quality***, both throughout a process that cannot be turned off at five o'clock. Adopting the quality equation is a decision and a commitment one makes every day that never goes away, that needs to be sustained all year long to become a habit. Institutional quality and qualified people are the key to making quality products, with the best possible use of the ordinary distribution of human talent and a permanent awareness of personal and institutional limitations [25].

Service quality: The privilege to assist in preserving and improving life provides us with much professional satisfaction. But, do we have the necessary background to fulfill the humanistic demands of our profession? Often, one recognizes professionals who have mastered scientific facts and surgical techniques but who lack interpersonal skills and respect for the dignity of man, empathy, and humility. Remember that our attitude often trickles down to the entire team! [26].

To achieve this, a combined approach is necessary, inducing change from the top, by influence or persuasion and commitment to education, and encouraging bottom-up grassroots involvement and cooperation. Promoting bottom-up chances is an important component of Edwards Deming's principles of total quality management. Both the top-down and the bottom-up approaches are not mutually exclusive but rather complementary and are what is meant by **T**otal **Q**uality **M**anagement.

• Total Quality Management (TQM) is a business strategy aimed at embedding awareness of quality in all organizational processes making it the responsibility of all employees.

• TQM requires a re-organization of the work process and the workplace by application of principles of "teamwork" and work "teams" that are supposed to involve the workers and give them greater control in their work

Quality problems and categories of poor quality: Overuse, underuse and misuse of funds due to: defensive medicine, ignorance, the culture of money, poor attitude, lack of knowledge, resources, or technology, as well as corruption, greed, etc. Reforms such as revisions to the fee-for service reimbursement and the incentive it provides for overuse can result in significant savings [27,28]. In other words, health care providers who ensure quality care, customer satisfaction, cost control, and efficient and appropriate use of resources, are preferred.

Reporting of quality

• *Lay media*: Anecdotal; substantiation not required; short-lived;

• *Professional literature/media*: Scientific process; scrutinized data; longer lasting;

• *Value of representation in both lay and professional media*: Credible evidence-based outcomes, that are recognized in the professional literature and attract the interest of the lay media provides the best of both worlds.

Quality of care: Using "network science", a method of analysis that examines webs of connections in complex systems, it is possible to map the "*Product Space*" by depicting clusters of capabilities/products grouping them according to their relatedness. The concept of "*proximity*" formalizes the intuitive idea that the ability of a center to generate an outcome depends on its ability to produce other ones — "*structure of production*". When a center with many complex capabilities adds a new capability, it can create a range of new possible products — new complex procedures. Conversely, adding a single new capability in a center that has few to begin with won't leverage an existing matrix of capabilities in the same way, indeed it might not produce any new products at all [29].

Systems of care, their impact on quality: Although the knowledge and practice of individual clinicians are important for high-quality care, today we realize that no health care professional can deliver high quality alone; therefore, health care professionals prefer to practice within groups — proximity — and systems of care. *Systems of Care equal institution plus staff partnership plus product space plus structure of production* [29,30].

Institutional variations in hospital mortality associated with inpatient surgery

• Rates of death vary across hospitals, from 3.5% in low-mortality hospitals to 6.9% in high-mortality hospitals;

• High mortality hospitals have complications rates similar to those of low mortality hospitals (24.6% and 26.9%, respectively) and of major complications (18.2% and 16.2%, respectively);

• Mortality in patients with major complications was almost twice as high in hospitals with high mortality than in those with low mortality — high velocity organizations — (21.4% *vs*. 12.5%, $P<0.001$). Hospitals with higher mortality rates — the pack — are less effective in rescuing patients from complications;

• Timely recognition and effective management of complications are important in reducing deaths after surgery;

• The value of avoiding complications is obvious. The quality of care once *complications have occurred is crucial for reducing mortality* [30].

Business intelligence: how are we doing?

Business intelligence — the systematic use of information about one's business — is vital to understand, report on, and to predict different aspects of performance. High quality intelligence capabilities and analytic skills play crucial roles in the most competitive sectors of the global economy because it can avert bad events providing that the dots are properly linked.

How are we doing? Due to the current demand for excellence and transparency, hospitals should start collecting and analyzing data — a method to evaluate future improvements — about outcomes calling for quality from their practitioners in preparation for a not too distant future. Implementing an independent measurement and a reporting system — business intelligence — focused on patient safety with a view to eventually making the information available to the public, will have an impact on quality, as well as on consumer and patient satisfaction.

An accurate and unbiased statistical analysis of surgical outcomes allows for an intelligent search of the risk factors, continuous improvement through responsiveness of the parts and the course of actions, as well as for a valid comparison with other institutions. The truth is the truth wherever it is found and to dismiss it because it comes from people with different views is a mistake. Undoubtedly, gathering accurate information is vital also because politicians, bureaucrats and company officials are often wary about alarming citizens.

The systematic use of information requires good data and commitment of executives to fact-based and analytical decision-making as a way to learn rather that doing it out of gut feeling or intuition — *cognitive illusions, illusion of validity* [31]. Gathering solid data, working analytically, and leaving emotions aside all help those on the top to reflect critically on their own behavior, and then change how they act to make better decisions. Efforts to develop fact-based decision-making capabilities are likely to fail unless they are closely supported by top management.

High performance organizations adapt and thrive by rapidly making choices that others do not by moving the decision making process down, close to the generation of information and around the needs of the user, instead of moving the information up to the executive suite.

The people who construct statistics are very often not the same kind of people needed to publicize them. An effective leader should be able to comprehend number-laden reports, evaluate the information provided to him, and draw conclusions from data, rather than be dependent on others to interpret for him.

Altogether, evidence-based medicine improves patient care using metrics and evaluations as a tool for learning rather than accounting.

Two categories:

Reporting: Those providing services to the public, needs to report accurately on what is going on in their business. By getting a relatively early warning on their performance they can fix the problems and educate the team members encouraging their participation with a button up plus horizontal approach.

Analytics: This is more understanding-oriented in terms of knowing what factors are really driving your business performance, or prediction-oriented, looking forward instead of backward.

Inferences

• Cardiac Surgery is not immune to the waves of innovations — Kondratieff waves — sweeping the world at large over the past fifty years starting with disruptive new technologies that have tranformed industries, societies and economies beyond recognition. Developing economies have been spared this technological onslaught, but they might soon have this same problem [32]. As President J. F. Kennedy put it, "Great change dominates the world, and unless we move with change, we will become its victims".

• An innovative partnership among the government, the private sector and foundations can led to major advancement of the health system.

• Listening to customers is in general a good idea, but it is not the whole story; in order to innovate smart companies should sometimes ignore what the market says it wants today, relying on inspiration and even distorting reality for the genesis of new products.

• We should be prepared for changes in the patient population requiring surgery. Conventional surgical procedures are expected to diminish. Hybrid procedures, requiring special facilities and team work with the participation of people with different skills will be more often adopted.

► Part III will be published in the next issue of the RBCCV

Pediatric Cardiac Surgery: a discipline on its own

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?

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