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Lessons learned during my collaboration with Alain Carpentier: A 25-year perspective

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Over the past three decades, mitral valve repair has undergone a profound transformation, driven by an increasingly close collaboration between surgeons and imaging specialists. In this evolution, intraoperative echocardiography has progressively evolved from a purely diagnostic modality into a central tool for surgical planning and quality control.

My collaboration with professor Alain Carpentier, initiated in the early 1990s and continuing for more than 25 years, provides a unique perspective on this transformation [1]. It illustrates how the integration of echocardiography within surgical decision-making processes has contributed to improving both procedural success and long-term durability of mitral valve repair.

Four key lessons can be identified from this experience: understanding the surgeon's needs through a functional and pathophysiological approach, developing a standardized intraoperative echocardiographic protocol based on a common language, actively contributing to surgical innovation and ensuring effective transmission of knowledge to future young generations.

Beyond technical considerations, these lessons reflect a broader paradigm: the heart team as a unified entity, in which echocardiography acts simultaneously as a guide and a safety net.

1. Understanding the surgeon's needs: the pathophysiological "triad"

A major conceptual advance in mitral valve repair has been the introduction of a structured framework or pathophysiological "triad" based upon the clear distinction between aetiology, lesion and dysfunction. Each of these components carries specific implications: aetiology determines prognosis, lesions guide surgical techniques and dysfunction defines the objectives of repair.

This framework marked a shift from purely anatomical descriptions toward a functional analysis centred on leaflet motion. In this context, Carpentier's classification remains fundamental, particularly in clarifying terminology and avoiding confusion between prolapse, billowing and flail. Importantly, prolapse must be defined as a dysfunction rather than a disease.

The functional approach has clarified a complex field and enhanced surgeon – echocardiographer communication. It is based upon three essential principles for a durable mitral valve repair: restoration of an adequate coaptation surface, preservation or recovery of leaflet mobility and systematic annular remodelling using ring annuloplasty.

For echocardiographers involved in intraoperative imaging, understanding these principles is essential. Their role is not to replicate surgical analysis but to provide complementary information, particularly regarding functional assessment in a beating heart.

2. Developing a standardized intraoperative echocardiographic protocol

Effective collaboration within the operating room requires a shared and structured language. Early experience highlighted the need to improve echocardiographic reporting so that it would be precise, concise, reproducible and directly relevant to surgical decision-making. This led to the development of a dedicated intraoperative protocol structured around key elements: dysfunction, lesion, aetiology, risk of systolic anterior motion (SAM) and associated valve assessment.

In the seminal paper, "The French Correction", published in 1983 [2], Alain Carpentier clearly mentioned that "Surgeons are not concerned with lesions. We care more about function". This standardized approach enables a clear and efficient dialogue between echocardiographers and surgeons, a true partnership (Fig. 1).

The "6 views – 5 measurements" protocol constitutes the backbone of this methodology. It ensures systematic evaluation of the mitral valve using multiplane 2D transoesophageal echocardiography, enabling accurate segmental analysis and reliable quantification of key parameters.

Three-dimensional echocardiography has further enhanced this approach. By providing a surgical view of the valve, it improves spatial understanding and facilitates communication within the team. It is particularly valuable in complex lesions, such as commissural involvement,

Abbreviation: SAM, Systolic anterior motion..

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Fig. 1. IOE in mitral valve reconstruction: the power of partnership. TOE: transoesophageal echocardiogram.

in the assessment of indentation and a unique ventricular view of mitral valve. Importantly, 3D imaging complements rather than replaces 2D echocardiography. A combined approach ensures both diagnostic accuracy and intuitive interpretation.

3. The two-step intraoperative strategy: pre-pump and post-pump assessment

Intraoperative echocardiography plays a pivotal role at two key stages of mitral valve repair.

The first stage, pre-pump evaluation, consists of a detailed analysis of valve pathology. This step is crucial, as it provides the surgical roadmap and enables a shared understanding between the surgeon and the echocardiographer. The second stage, post-pump evaluation, is equally critical. It allows assessment of the immediate result of repair under physiological conditions and ensures that the repair meets quality criteria before completion of the procedure.

Post-repair assessment must be rigorous and standardized. Optimal haemodynamic conditions are mandatory and several parameters must be systematically evaluated, including coaptation height (≥ 8 mm), leaflet mobility and presence of residual mitral regurgitation and/or SAM.

A key challenge is distinguishing transient from permanent residual regurgitation. Only permanent defects should prompt immediate surgical correction. More importantly, identifying the mechanism of residual regurgitation, rather than assessing severity alone, is essential to guide appropriate corrective strategies. In this setting, echocardiography becomes a true decision-making tool and confirms its key role within the Heart Team.

4. Contributing to surgical innovation

Echocardiography has both enabled and advanced mitral valve reconstructive techniques. A prominent example is the understanding of SAM. Echocardiographic analysis has demonstrated that SAM results from an imbalance between excessive leaflet tissue and reduced mitral orifice size, frequently associated with undersized annuloplasty. This insight has led to major modifications in surgical strategies, including appropriate ring sizing and reduction of posterior leaflet height.

Similarly, echocardiography has contributed to redefining the approach to Barlow disease. Identification of specific echocardiographic patterns has allowed simplification of repair techniques in selected patients, emphasizing the importance of annular dynamics rather than solely valvular anatomical lesions.

These observations illustrate that innovation in mitral valve repair arises from continuous interaction between imaging and surgery. Echocardiography not only evaluates outcomes but also informs surgical concepts and techniques.

The ultimate objective of mitral valve repair is long-term durability. Beyond immediate surgical success, the goal is to achieve a lasting correction that provides sustained clinical benefit. Echocardiography plays a key role in this context by enabling accurate long-term follow-up and early detection of recurrent mitral regurgitation. It also reinforces adherence to fundamental principles, particularly the importance of annuloplasty in maintaining valve competence.

Despite considerable advances, “real-world” data indicate that early referral and repair rates remain suboptimal. This finding highlights the need for better dissemination of expertise and wider implementation of standardized approaches in specialized heart valve centres.

5. Ensuring transmission of knowledge to young generations

Sustained progress in mitral valve repair depends on effective transmission of knowledge. Education was a central element of Carpentier’s vision and remains a major priority.

Training initiatives, including dedicated courses and international collaborations, have contributed to disseminating expertise and promoting the Heart Team approach. More recently, simulation-based training has emerged as a powerful tool to teach intraoperative echocardiography and surgical techniques.

Standardized protocols can also be transmitted through simulation, improving reproducibility and accelerating learning curves. Emerging technologies, such as artificial intelligence and virtual reality, are expected to further enhance training and predictive capabilities. However, beyond technological innovation, education remains fundamentally a human process based on mentorship, experience and shared commitment.

6. Conclusion

The experience gained over 25 years at the interface between echocardiography and mitral valve reconstruction underscores the importance of full integration and partnership within the Heart Team in expert mitral valve centres. Understanding surgical needs, establishing a common language, contributing to innovation and ensuring effective transmission of knowledge are major lessons learned with Alain Carpentier. I owe my entire professional career to him. Beyond that, we have forged an unbreakable bond, a relationship that is not only scientific but also deeply human. This filial bond will last forever.

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Disclosure of interest

The author declares that he has no competing interest.

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