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“I was stimulated to be part of the change, and inspire further females towards a similar path”

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## Q1 What initially sparked your interest in paediatric cardiology?

My venture into paediatric cardiology began during my medical studies at the University of Padua, Italy. During my clinical rotation in paediatrics, I discovered the remarkable fact that children could survive with only one ventricle. Their treatment, or rather palliation, had been discovered only four decades earlier, leaving many questions open to debate, especially on the long-term management of these patients. I was incredulous at first, and decided to shadow a paediatric cardiologist examining a patient with a rare cardiac disease. To my amazement, upon entering the room, I found a teenager riding a bike to perform a functional test, who looked just like every other teenager. She wanted to be done with the examination, and go home to prepare for her planned ski weekend. Since nobody could tell her how many times she would be able to ski before being hospitalised again, she wanted to enjoy every second of her quality time. I was sincerely impressed from her disenchanting view on her reality, combined with genuine research for normality.

Since my very first day of preschool, I was resolute in my decision to become a paediatrician and, as stubborn as I am, I did not back up from that plan. This experience sparked an additional profound interest for the subspecialty of paediatric cardiology within me. At that point, I met my supervisor Ornella Milanesi, who guided

my first research project on the exercise capacity of patients with a single ventricle, and played a pivotal role in shaping my passion for paediatric cardiology. This mentorship added depth to my understanding of, and commitment to, evidence-based practice and research, combined with individualised patient-centred care.

As I progressed through my training in paediatrics at the University Children's Hospital of Zürich, Switzerland, I solidified my commitment to this subspecialty, and completed my training last summer. While I explored the complexities of congenital heart challenges, and continued to perform medical research on patients with a single ventricle, I was driven by a sincere desire to contribute meaningfully to their wellbeing.

## Q2 You are primarily interested in paediatric interventional cardiology. What initially sparked your interest in this area?

I embarked on my journey into paediatric interventional cardiology during my training in Zürich, where I first witnessed the world of minimally invasive procedures for congenital heart defects in the cardiac laboratory, led by Oliver Kretschmar. The dynamic nature of paediatric interventional cardiology awakened my interest in this specialised field. In fact, I soon realised that many of these interventions do not depend on standardised techniques with dedicated material. Beside performing non-invasive



procedures, the role of the interventionalist is also to adapt the material to the patient; to rethink the intervention according to the specific anatomy; and to understand when the intervention should be stopped, and the patient referred to surgery.

The integration of cutting-edge techniques and evolving technologies, with a certain level of personal inventive and manual work, was very appealing to me. Moreover, the possibility of completing the diagnosis of a congenital cardiac defect, and performing firsthand the intervention that resolves that defect, was similarly engaging. Lastly, I felt that the team in my institution had a similar mindset to mine, and I enjoyed working there, which is also very important when work takes up most of your day.

My dedication to advancing paediatric interventional cardiology extended to an advanced fellowship at the Hôpital Universitaire Necker-Enfants Malades in Paris, France. This experience in a high-volume

centre is broadening my technical expertise, but also deepening my appreciation for the transformative potential of minimally invasive interventions in paediatric cardiac care.

### **Q3** What do you think are the critical points of pursuing a career as a paediatric interventional cardiologist?

In the realm of academic meetings and discussions, there is often a predominant focus on success stories, creating an environment that tends to overshadow the inevitable challenges and setbacks that are integral parts of any professional journey. Acknowledging this reality, I approach my professional journey with a pragmatic perspective. The acknowledgment that success is not guaranteed, and that challenges are inherent in any ambitious pursuit, underscores my commitment to a realistic and grounded approach. The field of paediatric interventional cardiology is no exception, and while accomplishments are celebrated, it is equally important

to navigate the hurdles that come with the territory. While I cannot predict the trajectory of my career, I am earnestly working towards my goals, fully aware that difficulties are part of the journey. In this context, I have had the opportunity to meet other young paediatric cardiologists in a similar position, and learn how a community of practice can become the most relevant rescue net.

A further critical point remains that, in the context of interventional cardiology, females suffer a major underrepresentation. In fact, statistics from the adult interventional cardiologist show that only 4.5% of operators performing interventional procedures are female. The most 'classic' reason behind this relevant difference is the fact that such high-risk interventions in a highly competitive environment have historically been performed by our male colleagues. I was stimulated to be part of the change, and inspire further females towards a similar path, similarly to how

Guiti Milani, the chief of the catheterisation lab at the Hôpital Universitaire Necker-Enfants Malades, has been an inspiring figure for me in this regard. Being part of this transformative journey is not only about advancing paediatric interventional cardiology, but also about contributing to a more diverse and inclusive future in the field.

**Q4** In recent years, you have published several research studies. What would you say the key findings were?

Over the past year, our research has delved into various aspects of single ventricle patients' health. In fact, while surgical advancements have significantly improved short-term survival, long-term morbidity and complications persist as challenges. The focus of our research was on emphasising the importance of considering non-cardiac factors in enhancing the long-term outcome of these patients. The importance of factors such as preserved respiratory function, well-developed pulmonary vascular bed, and peripheral musculature development, are highlighted in our publications.

diaphragmatic paralysis, scoliosis, a higher number of interventions, and lower BMI. We assessed respiratory function and volumes in a further cohort of patients with a single ventricle, and raised concerns regarding potential compression effects on the left main bronchus, originating from implanted stents in the pulmonary branches. In fact, patients with stents displayed a larger right-to-left ratio for the main bronchus area, suggesting a certain degree of bronchial compression. These findings underscore the need for further investigation into the respiratory parameters of this patient group.

The abnormal development of pulmonary vascular bed in patients with a single ventricle significantly impacts long-term outcomes. Insufficient cross-sectional area of the pulmonary vasculature hampers the single ventricle circulation, and even minimal changes in pulmonary vascular resistance can cause significant alterations in cardiac output. Aggressive treatment of stenotic or hypoplastic areas, including percutaneous stenting, is deemed essential. A further study underscored the feasibility and safety of pulmonary stent implantation in cases of pulmonary stenosis, challenging potential reservations about adopting this approach. The growth patterns of pulmonary artery diameters post-stent implantation, especially the symmetric but limited growth with the contralateral side, offer valuable insights into the long-term effects of these interventions. Importantly, the results suggest that pulmonary artery stents should not be withheld when clinically indicated.

Peripheral muscular function also plays a crucial role in the context of a passive pulmonary flow, that

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One first multicentre, retrospective study examined the ventilatory function in patients with a single ventricle, revealing a high frequency of restrictive ventilatory pattern. This pattern, observed in 60% of patients, was associated with lower exercise capacity, and compromised quality of life. The study identified risk factors for ventilatory dysfunction, such as



also relies on a properly functioning muscular pump. Patients with a single ventricle often experience decreased exercise capacity, due to clinical deconditioning and reduced muscle mass. Guidelines recommend physical activity, but patients frequently fall short. Training programmes positively influence exercise capacity and quality of life. Our study uncovered a surprising disparity between traditional indicators of heart function or exercise capacity, and the daily physical activity levels of patients with a single ventricle. Despite the complexities of their condition, only 18% of these patients met the recommended daily threshold for moderate-to-vigorous physical activity. This finding is particularly intriguing due to the lack of correlation with conventional measures, emphasising the importance of considering broader aspects, such as quality of life and sleep quality, in understanding and promoting physical activity in this patient population.

In summary, our research results have brought forth a wealth of knowledge, spanning various non-strictly cardiological dimensions of single ventricle patients' health. These findings collectively contribute to a more comprehensive understanding of the challenges in managing these patients, while ongoing research remains crucial for guiding decisions on optimal timing, and considerations for interventions in this population.

**Q5** Are there any developments that you have seen in your research that you are particularly excited about seeing translated into practice?

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I am particularly enthusiastic about the advancements of our

investigation into predicting complications in the pulmonary arteries of patients with a single ventricle after surgery. Using a large patient database, we were able to create an algorithm to calculate a predictive score for anticipating complications in the pulmonary arteries after surgery (Glenn and Fontan surgeries). The independent risk factors that we observed were a larger ascending aorta, and a smaller left pulmonary artery.

The prospect of applying these findings to develop a pre-operative risk-stratification is intriguing, and has the potential to improve how we approach single ventricle patients undergoing such surgeries. This project aligns with our overarching goal of contributing to the evidence base for optimising the care of children with complex congenital heart conditions. I am enthusiastic about integrating these research insights into clinical practice, and test the relevance of our predicting score in other institutions.

**Q6** How have you seen the advent of new technologies, such as artificial intelligence (AI), significantly impact the field of interventional cardiology in recent years?

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In paediatric cardiology practice, we have not seen any clinical changes deriving from AI, and our daily work activity has remained unchanged, as of yet. Even the answers of this interview were formulated by me, and not generated by an AI assistant.

Nevertheless, the integration of AI into adult interventional cardiology has brought about notable transformations, significantly enhancing various aspects of patient care, and

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clinical workflows. For example, AI has been implemented in the analysis and interpretation of cardiac imaging in adults. Machine learning algorithms have demonstrated their proficiency in swiftly and accurately interpreting complex imaging data, such as angiograms and echocardiograms. Moreover, algorithms can assist in the precise measurement of anatomical features, and the identification of optimal routes for catheter navigation. This can not only expedite the diagnostic process, but also empower physicians to make more informed decisions during interventions.

However, it is important to note that when dealing with paediatric cardiology, this application of AI can be more challenging. The complexity and rarity of diseases in children pose unique obstacles. While the principles remain applicable, adapting AI technologies to the specific nuances of paediatric cases

requires careful consideration and ongoing research.

The move towards precision medicine has been another noteworthy impact in adult cardiology. AI's ability to analyse extensive datasets allows for the identification of patterns, and the prediction of individual patient responses to specific treatments. This facilitates a more personalised approach to interventions, optimising outcomes and risk assessment for each adult patient. This application of AI, if ethical consent is provided from all participants, could be of the highest value in our context of high-risk interventions, but only if used on a multicentre scale. In fact, a single institution rarely has enough patients for similar assessments.

In conclusion, AI has made remarkable strides in adult interventional cardiology, revolutionising diagnostics,

treatment planning, and risk assessment. As for paediatric cardiology, although more challenging, ongoing research and adaptation are essential to fully unlock the potential of AI, in addressing the unique complexities of paediatric cardiovascular diseases.

## **Q7** In terms of research, where can we expect to see your focus lie in the coming years?

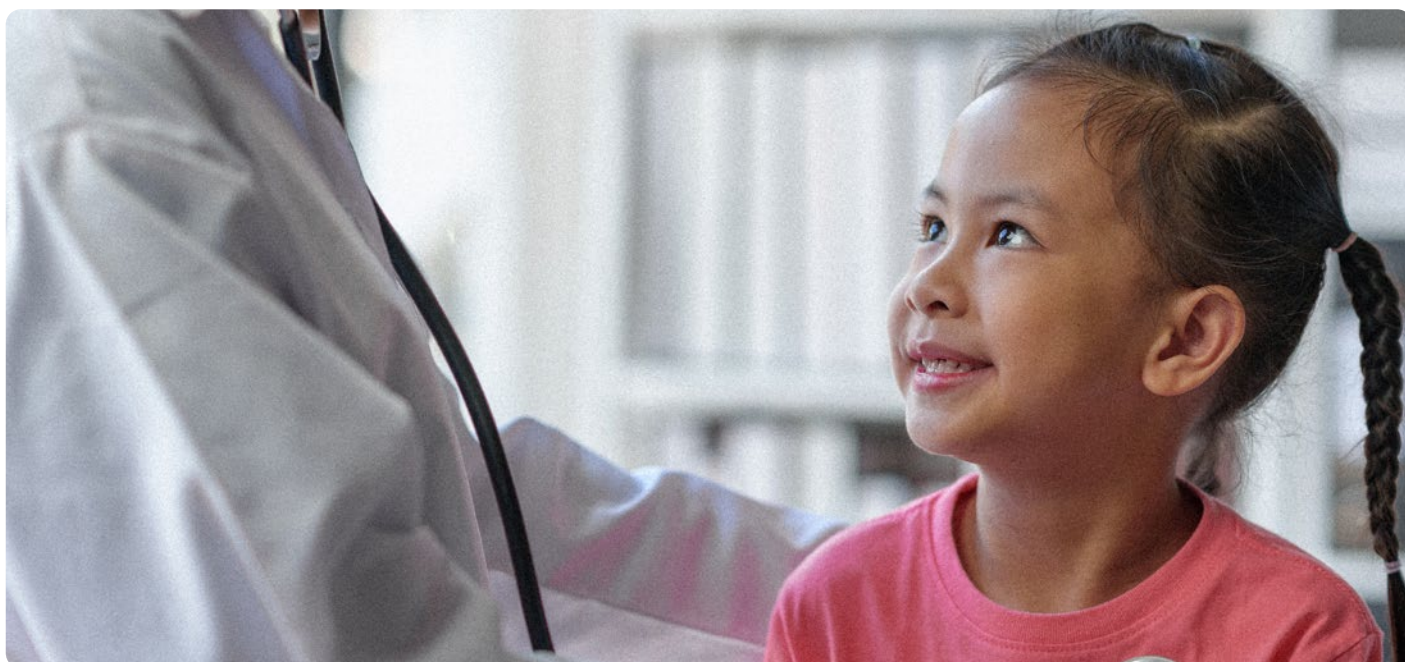
In the coming years, my research focus will continue to revolve around advancing the care and outcomes for patients with a single ventricle. One of the pivotal projects I am currently involved in explores a novel approach to optimise haemodynamic and clinical outcomes during the first stage of palliation for patients with hypoplastic left heart syndrome.

This project aims to evaluate the technical feasibility, the role

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**The complexity and rarity of diseases in children pose unique obstacles**

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of multimodal imaging, and the clinical outcomes of a totally percutaneous transcatheter technique, replacing traditional surgical procedures. The outcome study, that also involves computational fluid analysis and simulation, is being conducted at Hôpital Universitaire Necker-Enfants Malades.

These projects align with my overarching goal of contributing to the evidence base for optimising the care of children with complex congenital heart conditions. As I transition back to the University Children's Hospital of Zürich after my fellowship in Paris, I anticipate further collaborative efforts, in addition to our multicentric ongoing research initiative aimed at understanding and improving the coagulation profile of these patients.

### **Q8** What are some points of emphasis you incorporate into practice, to be the best interventional cardiologist you can be?

I think it would be more correct to say, you 'try' to incorporate, especially since this is a list that describes the best clinical practice that I can imagine for a paediatric interventional cardiologist.

Patient-centred care should form the foundation of our approach. Understanding the details of the medical history, needs, and difficulties of each case, to tailor our medical approach to the patient's specific circumstances, is of the highest relevance.

Recognising the complexity of congenital heart conditions when working closely with a diverse team of specialists, including other healthcare professionals, is necessary to enable a comprehensive and well-rounded approach to patient care. Furthermore, it is fundamental to recognise the limits of our techniques, to refer a patient to surgery without insisting on a percutaneous approach.

Continuous learning is also a cornerstone of this discipline. In the rapidly evolving field of interventional cardiology, we should commit to ongoing education and professional development, staying at the forefront of new techniques, technologies, and research findings. In this context, contributing to research that can improve patient outcomes and redefine standards of care should be pursued.

Having benefitted from valuable mentorship in my career, I am passionate about paying that back going forward. Engaging in mentorship activities, I wish to share knowledge and skills with the next generation of medical professionals, fostering a culture of continuous learning.

Quality improvement is another area of active involvement. Regularly reviewing outcomes, and seeking opportunities for enhancement in practice, allowing for adjustments and improvements in the delivery of care, are fundamental.

Upholding the highest ethical standards is non-negotiable. I believe that maintaining the trust and confidence of my patients and colleagues is essential for the integrity of my practice. Finally, compassionate communication should be promoted, since it ensures that patients and families feel heard, understood, and supported throughout their medical journey.

Through the integration of these principles into my daily practice, I aim to provide the highest standard of care, fostering positive outcomes, and an improved quality of life for my patients.