Could the mini 4D TEE probe help enable faster structural heart procedures?

How the miniaturized probe can deliver precise imaging without the risks of general anesthesia

TEE is an indispensable tool for structural heart disease diagnostics and transcatheter interventions, but associated risks have spurred interest in alternatives that could reduce esophageal injury and the need for general anesthesia. The challenge is finding a secure option that doesn't sacrifice image quality. A transformative solution is emerging in the 9VT-D mini 4D TEE probe. It's not only gaining attention for its clinical utility and patient benefits, but also for enhancing workflow efficiencies and the potential to reduce healthcare costs.

While traditional adult TEE has a favorable safety profile, it's been linked to complications, including oropharyngeal trauma, esophageal lesions, and chest pain. A 2020 study[1] involving 50 patients undergoing TEE-guided interventions found 86% had some degree of esophageal or gastric injury, with 40% experiencing complex lesions. Longer procedural time and poor or suboptimal image quality were associated with an increased risk.

With the growing prevalence of valvular heart disease[2] and trend for less invasive therapies, Dr. Konstantinos Papadopoulos of Interbalkan Medical Center in Greece is focused on strategies that minimize the need for general anesthesia and avoid intubation. It's particularly important given that a majority of his patients are elderly, frail, and have multiple comorbidities — leading to increasingly complex cases.

Interbalkan Medical Center is one of the leading cardiology centers in Greece. Dr. Papadopoulos is the Director of the Echo Lab, which utilizes advanced echocardiographic techniques, including 2D/4D transthoracic and transesophageal echocardiography, strain imaging, and stress echocardiography. The Interbalkan Medical Center performs 150-200 TAVI, 50 Mitral-TEER, 10-15 Tricuspid-TEER procedures, and more than 50 occluder device implantations annually for PFO, LAA, and ASD closure.

Dr. Papadopoulos and his team contributed to research supporting the use of the mini 4D TEE probe in everyday practice and for guiding transcatheter interventions. Their study published in 2024[3] involved a direct comparison with a standard adult TEE probe.

We recently asked Dr. Papadopoulos to share the experience, key findings from his research, and the potential impact of the probe on providers and patients.

What are the main challenges you face during structural heart procedures? What steps have you taken to overcome these challenges?

Dr. Papadopoulos: *The primary challenges include achieving optimal TEE imaging quality, which is crucial for procedural success, and ensuring seamless communication between the imaging specialist and the interventionist. To address these challenges, we conduct extensive heart team discussions on patient management and provide specialized*

training in cardiac imaging for interventionists to enhance intra-procedural communication. Our hospital also supports our imaging efforts by equipping us with state-of-the-art echocardiography machines and 4D probes, ensuring the highest imaging quality.

You are among the first physicians to use the mini 4D TEE probe in adult structural heart procedures. What were your initial impressions of the probe?

Dr. Papadopoulos: *I was impressed by the probe's exceptional image quality, despite its compact size and its original design for pediatric use. Regardless of the patient's weight, it consistently delivered excellent images, both in routine echo lab examinations and during cath lab interventions.*

TEE is a vital tool in transcatheter interventions where it aids in preoperative planning and intraoperative guidance. Can you expand on the mini 4D TEE probe's imaging capabilities?

"I was impressed by the probe's exceptional image quality, despite its compact size and its original design for pediatric use. Regardless of the patient's weight, it consistently delivered excellent images, both in routine echo lab examinations and during cath lab interventions."

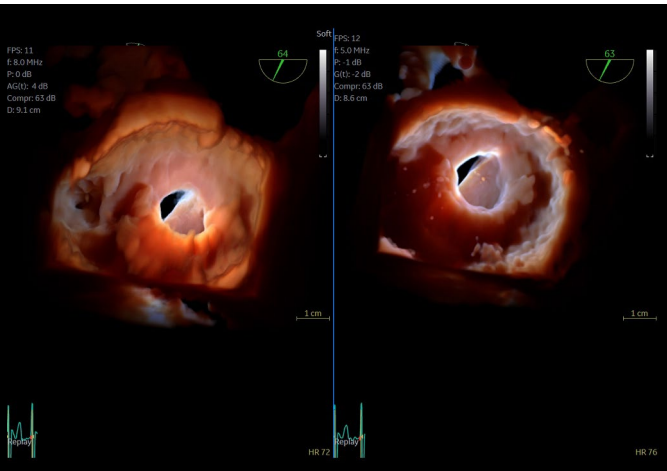
Dr. Papadopoulos: *Preprocedural planning and intraoperative guidance are essential for successful interventions. The mini 4D TEE probe offers outstanding 2D and 4D image quality with high frame rates. Compared to the standard adult TEE probe, there were no significant compromises in imaging resolution, which contributes to procedural effectiveness.*

What surprised you the most about the mini 4D TEE probe?

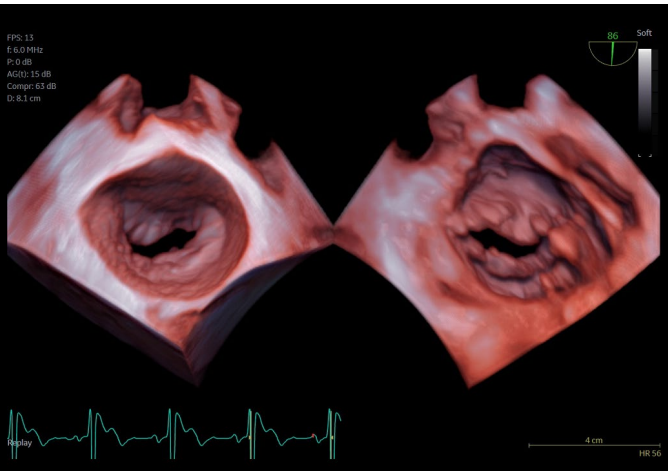
Dr. Papadopoulos: *The fact that such a small and flexible probe could deliver imaging quality comparable to a standard adult probe, especially in terms of 4D spatial resolution.*

You conducted a retrospective study,[3] 'Initial Experience with the 4D Mini TEE Probe in the Adult Population,' which involved 30 patients at Interbalkan Medical Center and Rennes University in France. What were your key findings?

Dr. Papadopoulos: *We found direct comparison with the adult TEE probe showed equivalent imaging quality. TEE examinations using the mini 4D TEE probe could be performed without sedation, using only local lidocaine, and transcatheter interventions could be conducted without general anesthesia or intubation.*



Flexilight/"photorealistic method" of en face views of a dysfunctioning metallic mitral valve. Direct comparison of images acquired with 9VT-D probe (left) and 6VT-D probe (right image)



Dual crop image of 3D en face view of normal mitral valve. Image enhanced with anatomic 1 map

> *"The mini 4D TEE probe offers outstanding 2D and 4D image quality with high frame rates. Compared to the standard adult TEE probe, there were no significant compromises in imaging resolution, ensuring procedural safety and effectiveness."*

Your study also concluded that the mini 4D TEE probe could reduce esophageal trauma. This is particularly important, given that past research has demonstrated 86% of patients undergoing structural cardiac interventions experienced TEE-related injuries. With the potential to reduce injury, how might this innovation impact the patient population?

Dr. Papadopoulos: *Our standard practice involves mild sedation for TEE procedures to enhance patient tolerance. Patients are often apprehensive about anesthesia and intubation. The ability to perform interventions without intubation is highly appealing, and the mini 4D TEE probe will definitely reduce complications. It reduces the risk of esophageal trauma from the TEE probe and tracheal trauma from intubation, as well as damage to the patient's teeth in the oral cavity of the trachea. Additionally, some patients experience adverse reactions to anesthetic agents, which may be avoided using the mini 4D TEE probe without general anesthesia.*

What type of patients could benefit from using a mini 4D TEE probe?

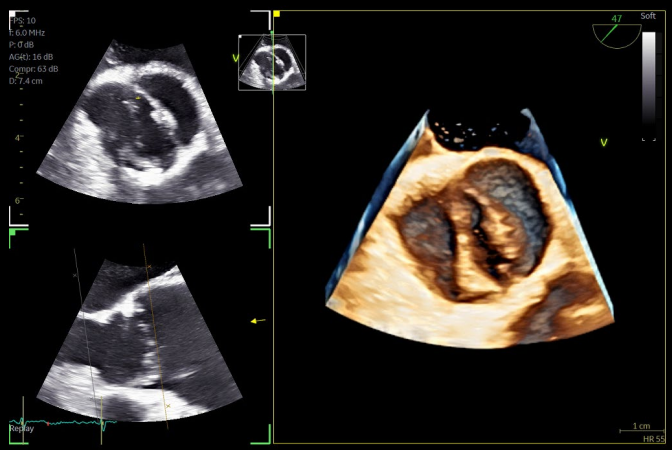
Dr. Papadopoulos: *In my opinion, the mini 4D TEE is attractive for all patients and preferable for the very young and the very old.*

PFO interventions are usually for people under 55 years old with cryptogenic stroke. Most of the ASD cases are young adult patients: 18, 19, 20-years-old. If you can perform it with just mild sedation and a very small probe, it's better for them.

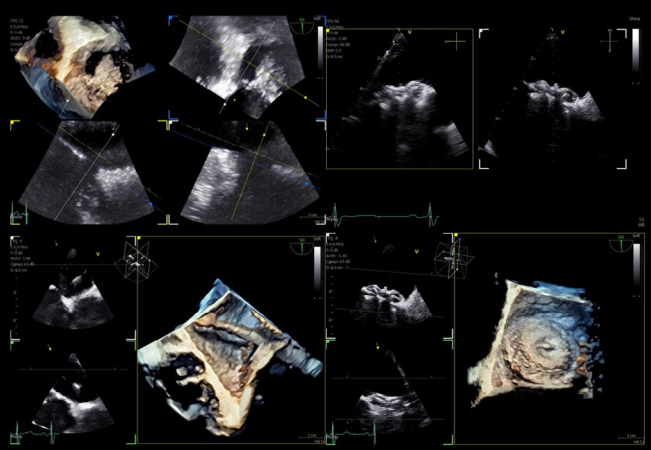
Some patients, particularly younger individuals, struggle with the standard adult probe due to oropharyngeal sensitivity, necessitating anesthesiologist involvement. The mini 4D TEE probe was well tolerated by nearly all patients without sedation, allowing them to drive home independently post-exam, with no complaints of odynophagia, chest discomfort, or hoarseness.

> *"The ability to perform TEE without the need for an anesthesiologist has streamlined our workflow."*

In older, frail patients, even mild sedation can cause a drop in blood pressure. We've had incidents where we have had to call anesthesia to help stabilize blood pressure, and there have been instances of respiratory arrest. So in really frail patients, we try to avoid intubation to really minimize risk.



3D en face view a "2-sinus of Valsalva" true bicuspid aortic valve



"ASD closure case." 3D evaluation of an "oval-shaped" secundum ASD with flexislice method and echocardiographic guidance for Amplatzer occluder implantation

How did the mini 4D TEE probe affect your workflow?

Dr. Papadopoulos: *The ability to perform TEE without the need for an anesthesiologist has streamlined our workflow. By avoiding intubation, you don't need to wait for the patient to wake up and be extubated, so you gain a lot of time. In high volume centers, where they need to perform back-to-back interventions, they can increase numbers and decrease hospitalizations. I've received feedback that if we don't intubate, we can safely discharge patients on the same day.*

> *"TEE examinations using the mini 4D TEE probe could be performed without sedation, using only local lidocaine, and transcatheter interventions could be conducted without general anesthesia or intubation."*

Did you experience any learning curve with the mini 4D TEE probe?

Dr. Papadopoulos: *No, no learning curve was required. The only main difference was the feeling of the probe, which was flexible.*

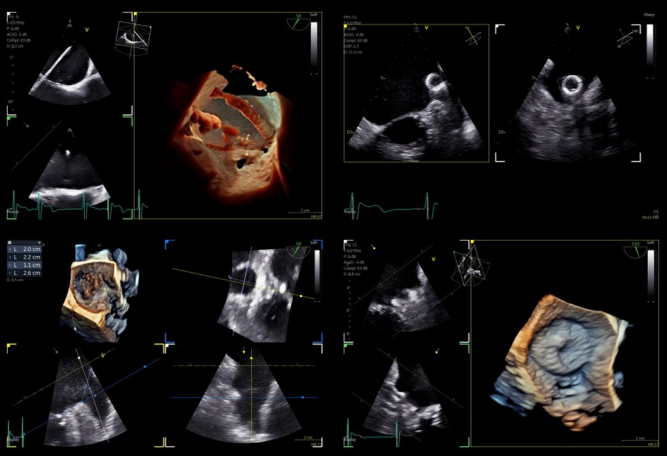
With the advantages you've outlined, how are you currently utilizing the mini 4D TEE probe in your center?

Dr. Papadopoulos: *We primarily use the mini 4D TEE probe in two scenarios: for patients who can't tolerate the adult probe or prefer to avoid sedation. We also use it for shorter interventions, such as PFO or ASD, that can be completed with mild sedation, rather than intubation. However, procedures such as Mitral-TEER can extend beyond an hour, requiring careful sedation management.*

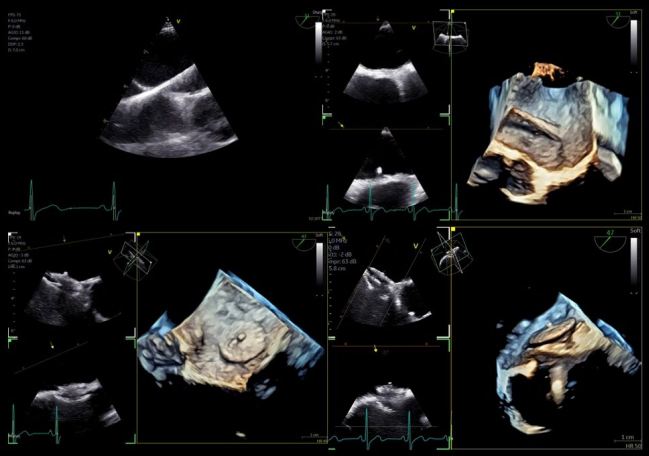
For echocardiologists, one common challenge is navigating the devices and communicating with the interventional cardiologist during the procedure. How do you address this challenge?

> *"In my opinion, the mini 4D TEE is attractive for all patients and preferable for the very young and the very old."*

Dr. Papadopoulos: *The close collaboration between the echocardiologist and interventionalist is very, very important. We emphasize meticulous pre-procedural planning as a team, ensuring proper device sizing and positioning. Our interventionalists learn how to appreciate echo images. While they may not know how to acquire the images, they understand how to read whatever is on the screen. During procedures, continuous transitions between 2D and 4D imaging provide excellent spatial orientation, facilitating precise navigation. Mastering this approach takes extensive training and experience.*



"LAA closure case." 3D evaluation of left atrial appendage with flexislice method and echocardiographic guidance for Amulet device implantation



"PFO closure case." 2D/3D echocardiographic guidance for PFO Amplatzer implantation

What do you see as the future of echocardiography and how will you and your team play a role?

Dr. Papadopoulos: *My ideal scenario would be to avoid intubation for all interventions by using smaller probes with full 4D capabilities. If future technology could provide an even smaller TEE probe without sacrificing imaging quality, it would further improve procedural efficiency and patient comfort.*

How do I see my role in the future? Echocardiography will remain the first-line imaging modality for patient evaluation, as it seamlessly integrates imaging with clinical information. My primary goal is to contribute to the training of colleagues, sharing advanced echocardiographic skills to ensure high standards across all cardiology departments. Additionally, through research and clinical experience, I aim to collaborate with the industry to enhance the quality of future generations of echocardiographic machines, optimizing their performance and expanding their capabilities. ■

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Konstantinos Papadopoulos, M.D., Ph.D., is a consultant cardiologist and Head of the Echocardiography Department at the 3rd Cardiology Clinic of the European Interbalkan Medical Center in Thessaloniki, Greece, specializing in advanced echocardiography. His expertise lies in interventional echocardiography, particularly in the planning and guidance of transcatheter interventions. He's also served as a consultant in a dedicated heart valve department. Dr. Papadopoulos has authored numerous publications in peer-reviewed journals and serves as a reviewer and editor for several PubMed-indexed journals. He's also actively engaged in educational initiatives, mentoring fellows, and conducting international training sessions in 4D echocardiography.

1 Freitas-Ferraz AB, Rodés-Cabau J, Junquera Vega L, et al. Safety of transesophageal echocardiography to guide structural cardiac interventions. *J Am Coll Cardiol*. 2020;75(24):3164-3173

2. Helmut Baumgartner, Bernard Iung, David Messika-Zeitoun, Catherine M. Otto, The year in cardiovascular medicine 2021: valvular heart disease, *European Heart Journal*, Volume 43, Issue 7, 14 February 2022, Pages 633–640, https://doi.org/10.1093/eurheartj/ehab885

3. Papadopoulos, K., Ikonomidis, I., Coisne, A., Özden Kayhan, Ö., Tzikas, A., Fragakis, N., Antoniadis, A.P., Vannan, M.A., & Donal, E. (2024). Initial experience with the 4D mini-TEE probe in the adult population. *Journal of Clinical Medicine*, 13(21), 6450. https://doi.org/10.3390/jcm13216450

9VT-D was introduced with the Ultra Edition release in August 2022 and is exclusively available on some Vivid systems. Please consult your local representative to confirm compatibility.

Dr. Papadopoulos is a paid consultant for GE HealthCare and was compensated for participation in this article. The statements by Dr. Papadopoulos described here are based on his own opinions and on results that were achieved in his unique setting. Since there is no "typical" hospital/clinical setting and many variables exist, i.e. hospital size, case mix, staff expertise, etc. there can be no guarantee that others will achieve the same results.

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